NEW

HOW IT WORKS

DID YOU KNOW?

Revealing the truth behind life's biggest mysteries

Welcome to

Is it possible to 3D print your own car from an open source design? Is there a jetpack that can fly for 30 minutes? Were the elements that make up our bodies forged inside ancient stars? Can you listen to music through your skull? All these questions and more are answered inside the pages of this book, so you can pursue knowledge like never before. What do you know?

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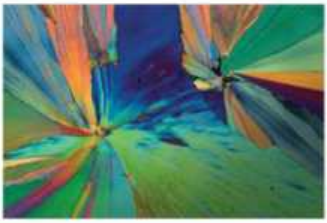

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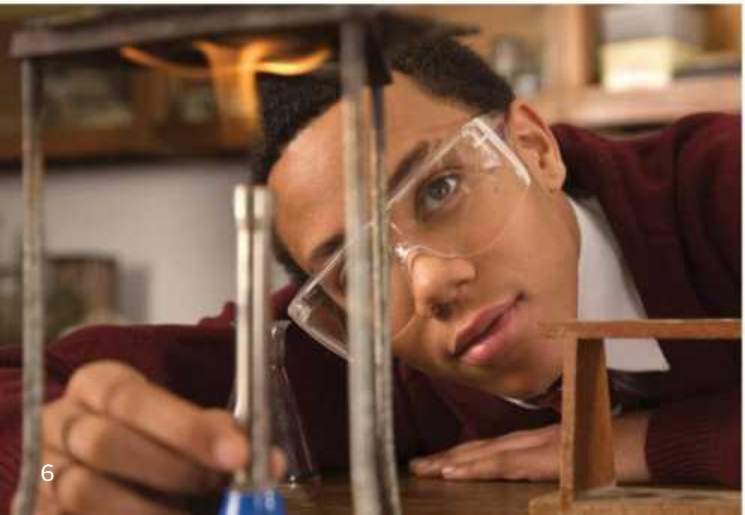

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DID YOU KNOW...

There are 206 bones in the human body

The 206 bones of the adult human skeleton make up a strong, flexible framework that protects our vital organs and allows our bodies to move, as well as being a mineral store and stem-cell reserve.

Bone is a composite material, constructed from three basic ingredients: collagen strands, a sugary protein glue and inorganic calcium salts. The collagen fibres are arranged in alternating layers, crossing over one another, providing a flexible scaffold, and calcium salts are glued in between for strength and rigidity.

The outside of each bone is composed of plates, or hollow tubes, of dense cortical bone, supported on the inside by a honeycomb network of spongy trabecular bone. This network is slightly flexible and helps to distribute the load, curving the tensile and compressive forces across the ends of the bone, while providing maximum strength.

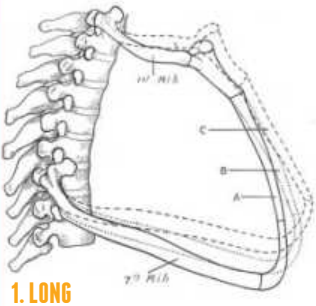
Spongy bone is also home to the bone marrow, and which houses stem cells capable of producing most of the cells of the blood and immune system. They are constantly active, and millions upon millions of new red and white blood cells are produced every minute.

Embedded within the bone matrix are cells known as osteocytes. They do not move, but are capable of detecting stresses inside the bone itself, and can trigger the formation of new bone in a process known as remodelling. The old bone is broken down by large cells known as osteoclasts, and new collagen and minerals are deposited by smaller osteoblasts.

Together, the two cell types are able to release and store calcium and phosphorous in the skeleton for use elsewhere in the body. They are under the influence of hormones released by glands in the brain, and when levels of minerals run low in the body, the signals encourage the osteoclasts to begin wearing away at the surface of the bone, releasing minerals into the bloodstream. When mineral levels are high, osteoblasts lay down new bone, replenishing the store.

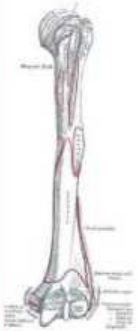
The major function of the skeleton is to provide a structural framework for the muscles that move our bodies

LONG BONES



1. LONG SEVENTH RIB

The seventh rib, which is the lowest fixed rib, is the longest bone in the rib cage, measuring about 24cm (9.5in) in length.



2. LONGER HUMERUS

After the three leg bones, the next-longest bone in the human body is the humerus in the upper arm, measuring around 36cm (14in).

3. LONGEST FEMUR

The femur, or thigh bone, is the longest bone in the human body by some margin, measuring around 50cm (20in) in the average adult.

"The two cell types are able to release and store calcium and phosphorous in the skeleton"

DID YOU KNOW...

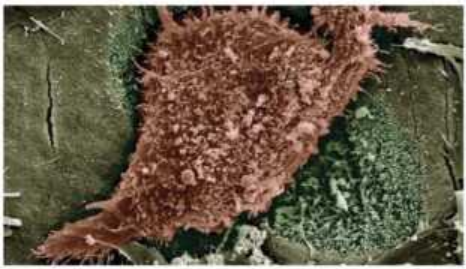
BONE STRUCTURE

ARTICULAR CARTILAGE
The end surfaces of the bones are covered in thick, slippery cartilage, preventing wear at the joints

COMPACT BONE
The outside of the bone is arranged in an orderly, layered structure, providing strength and rigidity

EPIPHYSIS
The ends of the long bones act as shock absorbers, with a casing of tough compact bone supported by a spongy core

PERIOSTEUM
The outside of the bone is covered in a layer of connective tissue, containing cells involved in growth and repair

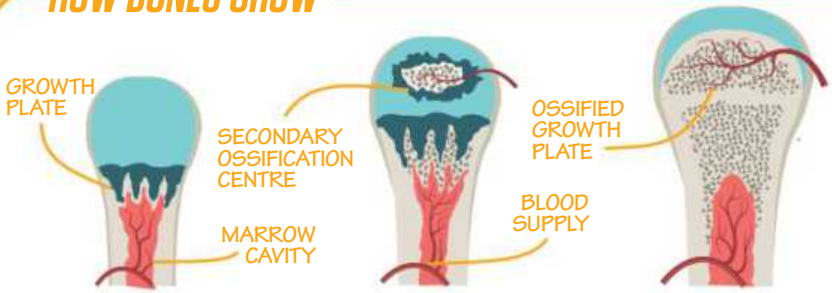


Cells known as osteoclasts constantly remodel the surface of bone

DIAPHYSIS
The shafts of the long bones are constructed from densely packed compact bone

MEDULLARY CAVITY
The centre of the long bones is filled with yellow bone marrow, containing mainly fat cells

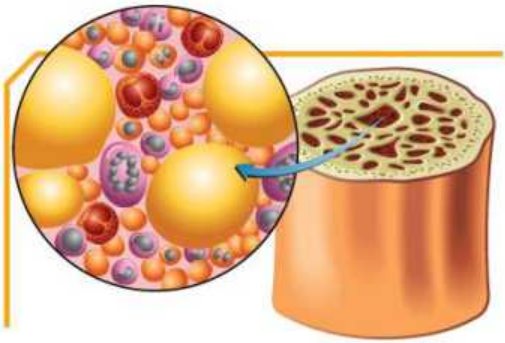
HOW BONES GROW



NEWBORN
In the womb, most of the skeleton is made of cartilage, but gradually minerals are laid down and it is converted to bone in a process known as ossification.

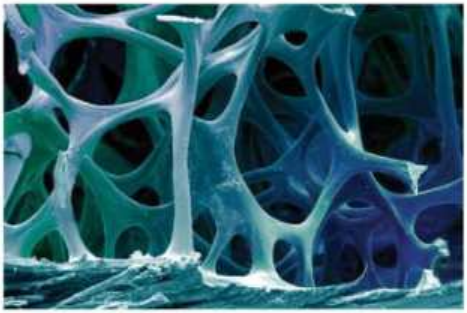
CHILD
Cartilage continues to form at the growth plates, and calcium salts are added at the secondary ossification centre, lengthening the bone at both ends.

ADULT
The growth plate itself is turned to bone, and stops producing cartilage, preventing the bones from lengthening any further.



BONE MARROW CELLS

There are two types of bone marrow in the human body; yellow marrow is found in the shafts of the long bones, like the femur, and red marrow is mainly found in the flat bones, like the ribs. Yellow marrow is mostly made up of large fat cells, whilst red marrow contains stem cells. These are capable of producing most of the cells of the blood and immune system, and concealed within the bones are many immature cells in the process of development.



Spongy bone has a characteristic honeycomb structure

RED BONE MARROW
Blood cells are produced in red bone marrow, found between the gaps in the honeycomb structure of the spongy bone at either end

BLOOD VESSELS
Blood vessels travel into and out of the bone through canals in the compact surface

ENDOSTEUM
The inner surface of the bone is lined by a single layer of cells

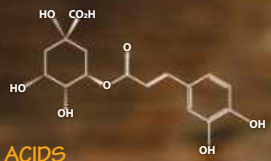
SPONGY BONE
This disorganised honeycomb structure is more flexible than compact bone, and its large surface area supports blood-cell production and calcium exchange

DID YOU KNOW...

Caffeine is an alkaloid

Whether it's a milky latte or a double shot of espresso, coffee has become an important morning ritual for many people all over the world. Its rich taste and aroma serves as a welcoming wake-up call and the caffeine helps keep you alert for the rest of the day, but did you know this is all down to the 1,000 different chemical compounds present in every cup? Acids, alkaloids, carbohydrates and proteins, either found in raw coffee beans or produced by the roasting process, work together to create a complex mixture of flavours and that distinctive coffee smell.

WHAT'S IN YOUR CUP?

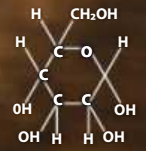


ACIDS

Coffee contains a variety of acids. Perhaps the most important is chlorogenic acid, which consists of two main compound groups. Dicaffeoyl acids impart a metallic, bitter taste while monocaffeoyl acids slowly decompose during the roasting process. This causes them to split into quinic and caffeic acids, which contribute to the coffee's bitter aftertaste.

ALKALOIDS

Although caffeine is probably the best-known alkaloid in coffee, Trigonelline prevents mucus-like acid by-products and other bacteria from sticking to your teeth, helping to prevent cavities. The roasting process creates aromatic compounds called pyridines. Pyridines are responsible for the coffee's sweet, earthy taste.



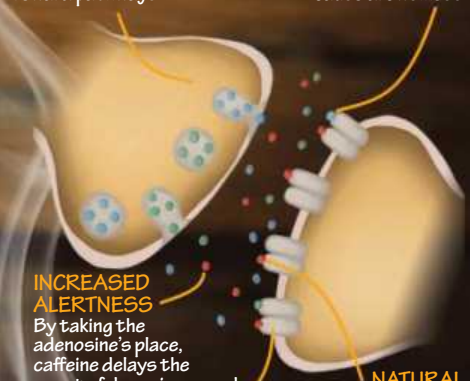
CARBOHYDRATES AND PROTEINS

Carbohydrates make up about 50 per cent of coffee's dry weight. They play an important role in the production of coffee's distinct aroma by way of the Maillard reaction, which takes place during the production. When the beans are roasted their free proteins combine with their sugars to form aromatic compounds.

CAFFEINE

Caffeine is a naturally occurring alkaloid and acts as a stimulant for the human brain. As a result, the adrenal glands produce adrenaline, the body's 'fight-or-flight' hormone, which causes your pupils to dilate, blood to flow to your muscles and sugar to be released into your bloodstream by your liver. When caffeine enters the body, enzymes in the liver also break off three metabolites from its compound structure. Theobromine increases oxygen and nutrient flow to the brain, paraxanthine increases the rate of fat breakdown to fuel muscle activity and theophylline increases your heart rate and reinforces concentration.

The recommended daily limit of caffeine intake is 400 milligrams (0.014 ounces), which is about three 237-millilitre (eight-ounce) cups of coffee, but if you were to consume more than ten grams (0.35 ounces) – that's about 75 cups of coffee – in a day, then it would become toxic and could lead to heart problems.



DOPAMINE REGULATION
Adenosine is also responsible for regulating dopamine in the brain, the hormone that activates pleasure centres and reward pathways

WITHOUT COFFEE
Normally, adenosine molecules bond to receptor cells in the brain to slow down nerve activity and cause drowsiness

INCREASED ALERTNESS
By taking the adenosine's place, caffeine delays the onset of drowsiness and increases alertness

WITH COFFEE
As caffeine is very similar in structure to adenosine, it can bind to the adenosine receptor cells and block the adenosine

NATURAL STIMULANT
Dopamine works more effectively while the adenosine receptors are blocked, contributing to that pleasant coffee 'buzz'

DID YOU KNOW...

Identical twins don't have identical fingerprints

Identical twins form when a single fertilised egg splits in two during the early stages of development, and as a result, the siblings share exactly the same genetic information. But our bodies are shaped not only by our genes, but also by our environment, and although the twins share the same womb, their environments are subtly different. Each twin is in a different position, and experience slight variations in contact with amniotic fluid. One might have a longer umbilical cord than the other, and one might receive more oxygen or nutrients. Fingerprints develop during the second trimester, and these small differences add up to produce noticeably different fingerprints.

Even if you can't tell the difference immediately, their fingerprints will give them away

Cold feet are caused by reduced blood circulation

© Dreamstime; Thinkstock

Cold feet are typically caused by reduced blood circulation. When your body is cold, it constricts your blood vessels, reducing blood flow to your skin in order to conserve heat around your internal organs.

In some people this reaction, called vasoconstriction, is triggered even at relatively warm temperatures, leading to cold feet and hands.

Cold extremities are quite common in cooler weather and are unlikely to indicate any serious medical condition. However, if they go white you may be suffering from Raynaud's phenomenon, a condition where arteries cut off almost all circulation to hands and feet in cold temperatures.

Bunsens are typically fuelled with natural gas, which is almost pure methane, CH4

The more oxygen there is the hotter a Bunsen burns

German chemist Robert Bunsen invented the Bunsen burner in the mid-19th century as a means to an end. His work focused on emission spectra, which is the bright light produced by different elements when they are heated in a flame. To carry out this experiment he required a hot, clean flame, which gave him the idea for the Bunsen burner. A modern Bunsen burner consists of a straight metal tube, measuring about 13 centimetres (five inches) long, attached to a base stand. A thin rubber tube known as a gas hose connects to the bottom and supplies gas to the Bunsen. The metal collar works to adjust the amount of air that enters the tube by altering the size of the air hole at the base. By allowing oxygen to mix with the gas, a hotter and more complete reaction occurs, causing a very hot, blue flame to be produced. It still has an abundance of laboratory applications today, including sterilisation and fixing cells to microscope slides.

DID YOU KNOW...

Your body is made of stardust

The elements that make up our bodies were forged inside ancient stars. Hydrogen is the smallest element, and formed in vast quantities after the Big Bang, along with a less plentiful supply of helium, and even smaller amounts of lithium and beryllium. But making the heavier elements required more energy. Hydrogen and helium gas clumped together to form clouds, and these clouds collapsed to form stars with enough heat and pressure to trigger nuclear fusion; inside the stars, the nuclei of hydrogen atoms slammed together, fusing to form helium.

As the stars aged, the helium atoms started to create even heavier elements, including carbon, nitrogen and oxygen. Depending on the mass of the star, this process sometimes continued, producing the nuclei of most of the elements up to number 26, iron. After this critical point, fusion reactions stop releasing energy. When stars run out of fuel, they collapse, kicking layers of gas and heavy elements into space.

For the most massive stars, this process involves a powerful explosion called a supernova, which provides enough energy to make the elements that are heavier than iron. The remnants of these old exploded stars mix with yet more hydrogen gas and go on to make more star systems, like our own Sun and planets, providing us with the range of elements we have on Earth today.

65% O

OXYGEN

Oxygen makes up over half of our body weight. It is one of the key components of water, and is one of the three essential elements needed to make biological molecules like fat and protein

18.5% C

CARBON

Carbon can make four bonds to other elements, making it the perfect scaffolding for building large, complex molecules. It is an essential component of fats, proteins, sugars and DNA

9.5% H

HYDROGEN

Hydrogen is the third element found in all biological molecules. There are actually more hydrogen atoms in the body than carbon or oxygen, but they are much lighter

3.2% N

NITROGEN

Oxygen, carbon and hydrogen make up the core of all biological molecules, but lots of other elements are used in smaller amounts. Nitrogen is found in both DNA and protein

1.5% Ca

CALCIUM

Calcium is found in bones and teeth, and also plays an important role in signalling between cells, in muscle and nerve function, and in blood clotting

P **1%**

PHOSPHORUS

Phosphorus, like calcium, helps to provide strength to bones and teeth. It is also involved in energy use, and is a vital component in DNA, helping to hold the whole structure together

K **0.4%**

POTASSIUM

Potassium ions are found dissolved inside cells and in body fluids. They carry an electric charge, and are used by nerve cells and muscle cells in the transmission of electrical impulses

S **0.3%**

SULPHUR

Sulphur is found in some of the building blocks of protein. It can make strong bonds to other sulphur atoms, helping to fix proteins into their 3D shapes

Na **0.2%**

SODIUM

Sodium is another electrolyte that carries charge inside the body. Along with potassium and chlorine, it is one of the key elements responsible for normal nerve and muscle function

0.4%

AND THE REST

There are many other elements in the human body, including chlorine, magnesium, manganese, iron, fluorine, cobalt, copper, zinc, selenium, molybdenum, iodine, lithium, and aluminium

Cl	Mg	Mn	Fe	F	Co	
Cu	Zn	Se	Mo	I	Li	Al

DID YOU KNOW...

Some people are immune to mosquito bites

Immune is not quite the right way to describe it, but some people are less attractive to mosquitoes due to smell. A study on twins conducted in 2015 showed a genetic link – identical twins are more likely to be equally attractive to mosquitoes than non-identical twins. But that's not all. While genetics play a role in body odour, there are lots of other factors that can contribute to our overall smell. Our body temperature affects the evaporation of scent molecules into the air, and mosquitoes are also attracted to the molecules that we exhale when breathing.

Eating spicy food kills off nerve endings

Tolerance for spicy food is partially inherited, but repeated exposure can also desensitise pain receptors. The sensation of eating spicy food is produced by the trigeminal system, which along with our sense of taste and olfactory system, allows us to perceive flavours. The capsaicin in spicy foods activates pain and heat receptors. Those who eat spicy food have less sensitive pain receptors. Eating spicy food regularly at a young age kills off nerve endings, increasing a person's tolerance.

As wood burns, hydrocarbons evaporate into the air, either bursting into flame or floating up as smoke

Smoke occurs when there isn't enough oxygen

Wood is made from a combination of water, hydrocarbons, and minerals. As the temperature rises above 149 degrees Celsius (300 degrees Fahrenheit), the hydrocarbons start to vaporise, floating up into the air. They combine with oxygen, burning and releasing energy that is visible as a hot flame. As they burn, they release carbon dioxide and water vapour, both colourless gases that you cannot see.

Sometimes there is not enough oxygen for these evaporated components to burn, and instead, they continue to float upwards, rising in the hot air. The evaporated oils and tars clump together as they rise, forming fine particles known as smoke. The particles move about randomly, and as they collide with the invisible particles that make up the air, they change direction, producing the ever-changing swirling patterns of smoke.

After all of these volatile hydrocarbons have evaporated, all that is left is charcoal, nearly pure carbon. The charcoal does not evaporate, so as it burns there is no flame, just glowing embers. Once the charcoal is gone, all that remains is ash, the minerals like magnesium and potassium that do not burn at all.

DID YOU KNOW...

A lack of friction enables ice skaters to perform

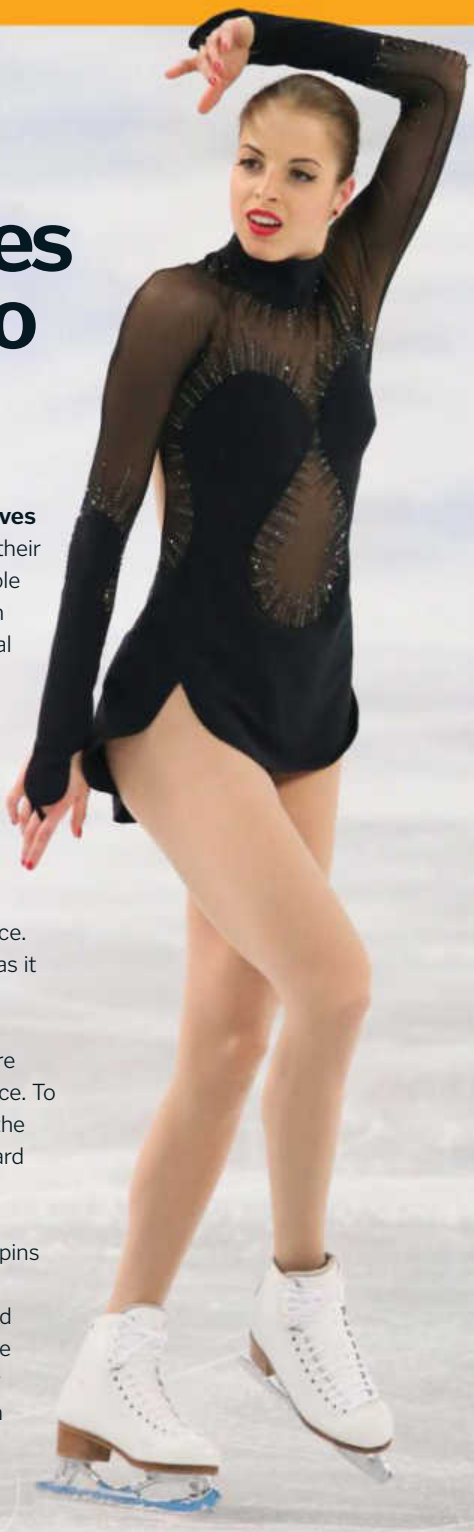


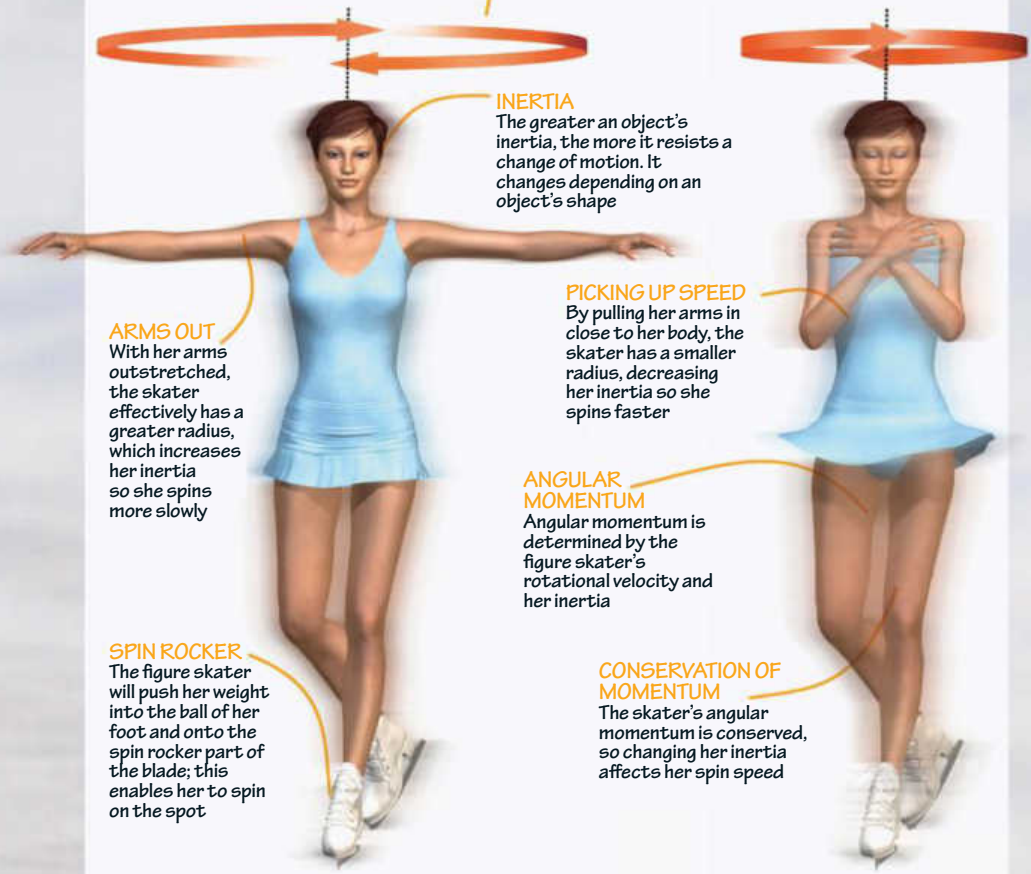
Figure skaters appear to glide effortlessly across the ice, performing breath-taking moves and spins, often at unimaginable speeds. At their core, these impressive performances rely on simple scientific principles, including friction, momentum and Newton's third law – every action has an equal and opposite reaction.

It's actually a lack of friction and the physical properties of the ice that enable a skater to glide, turn, speed up and stay in motion during a routine. Friction is a resisting force that occurs when two objects slide against one another, dissipating their energy of motion. A figure skater performing on smooth ice with sharpened skates will therefore encounter very little resistance. Some friction is still required for skating, though, as it enables skaters to start a stroke and come to a complete stop.

Newton's third law helps to explain how a figure skater is able to move and execute jumps on the ice. To put it simply, a skater will apply force down onto the surface of the ice; the ice then generates an upward force, which pushes back and helps to propel the skater into the air.

Figure skating routines that feature dramatic spins also rely on angular momentum. The amount of momentum depends on the skater's weight, speed and the distribution of mass from the centre of the body. Because of this, skaters will often tuck their arms in during a spin to reduce their radius, which in turn enables them to pick up more speed as they spin.

SCIENCE OF SPINNING



RADIUS
The skater's inertia is affected by her mass and her 'radius' – her limbs' distance from the central axis of rotation

INERTIA
The greater an object's inertia, the more it resists a change of motion. It changes depending on an object's shape

ARMS OUT
With her arms outstretched, the skater effectively has a greater radius, which increases her inertia so she spins more slowly

PICKING UP SPEED
By pulling her arms in close to her body, the skater has a smaller radius, decreasing her inertia so she spins faster

ANGULAR MOMENTUM
Angular momentum is determined by the figure skater's rotational velocity and her inertia

SPIN ROCKER
The figure skater will push her weight into the ball of her foot and onto the spin rocker part of the blade; this enables her to spin on the spot

CONSERVATION OF MOMENTUM
The skater's angular momentum is conserved, so changing her inertia affects her spin speed

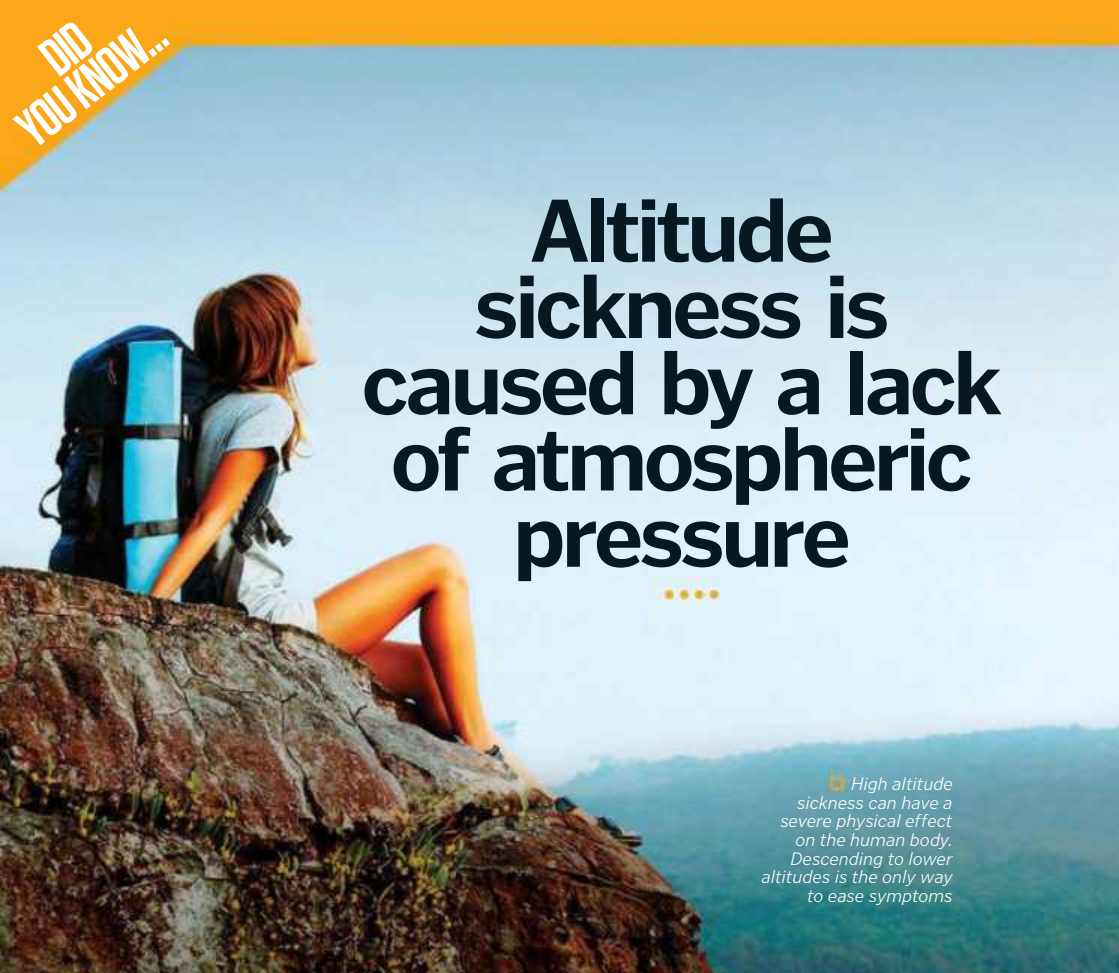
FIGURE SKATE DESIGN

Figure skates' unique design helps to ensure the athlete is able to glide and complete complex manoeuvres on the ice. The prominent metal blade, which is attached to the bottom of the boot, has a slight inward curve added when it is sharpened. This is known as the rock and offers two edges to skate upon, the inside and outside edge. Skaters will use the edges to move across the ice and pick up speed. It's also possible to skate on both edges, which is known as skating on flat.

The sweet spot, which is just below the ball of the foot, is known as the spin rocker and is the area on the blade that the skater will use to spin. The spikes at the tip are called toe picks and are used primarily for fancy footwork and jumping.

DID YOU KNOW...

Altitude sickness is caused by a lack of atmospheric pressure



High altitude sickness can have a severe physical effect on the human body. Descending to lower altitudes is the only way to ease symptoms

Adventurous explorers can spend months training prior to scaling mountain peaks, but regardless of fitness level, high altitudes can take a toll on the human body.

Between around 1,524 and 3,505 metres (5,000 and 11,500 feet) above sea level is considered high altitude. Most travellers will start to feel the effects of high altitude sickness as they attempt to acclimatise to the change in atmosphere at these heights. The most common symptom is shortness of breath, which is due to a lack of atmospheric pressure. At these heights, air molecules are more dispersed, so less oxygen can be inhaled. In order to compensate, your heart rate will increase and the body will produce more red blood cells, making it easier to transport oxygen around the body.

The low humidity levels at high altitude can also cause moisture in the skin and lungs to evaporate quicker, so dehydration is a real threat. Your face, legs and feet may start to swell as the body attempts to retain fluid by holding more water and sodium in the kidneys.

Difficulty sleeping is also common, and symptoms of high altitude sickness can get progressively worse the higher you climb, including mood changes, headaches, dizziness, nausea and loss of appetite.

A Nobel Prize was awarded for an explanation of hula-hooping

THE FORCES BEHIND HULA HOOPING

Although hula hooping comes relatively naturally to most of us, it's actually quite a complex task from a biomechanical viewpoint. In fact, the 2004 Nobel Prize in Physics was awarded for an explanation of hula-hoop dynamics.

The hoop is able to spin due to the momentum created by pushing your hips and stomach back and forth, and by slightly shifting your weight as it spins. The reason the hoop keeps spinning is due to the forward motion of your hips, and not because of any circular movement, which is wrongly implied by the word 'hula' in its name.

This activity has recently gained in popularity due to its potential health benefits. It works the abdominal muscles in your core and studies have shown that using a weighted hoop may help to burn visceral fat, which can be detrimental to the heart.

DID YOU KNOW...

Crystallised alcohol is a multitude of colours

If you leave a drop of an alcoholic beverage, to dry out, the water and alcohol will eventually evaporate to leave behind crystallised sugar. If you then look at this sugar through a polarising microscope, you will see a pattern of bright colours as light refracts through the crystals.

The effect is created using two polarising filters, one between the crystals and the light underneath them, and another positioned at a 90-degree angle from it, between the crystals and the microscope lens above them. As these filters force light waves to oscillate in one direction, rather than all different directions as they would normally, the two polarising filters should block the light completely. But when the light passes through the crystals, it refracts, allowing it to pass through the filters at different angles so we see lots of vibrant colours. Geologists use the same technique to study the structure and composition of rocks.

Crystallised alcohol refracts the lights that hits it, causing a plethora of colours

DID YOU KNOW...

It is entirely possible for a singer to shatter glass

There must be microscopic defects big enough to allow the glass to buckle

All objects have a frequency at which it vibrates. Sound waves from the singer's voice vibrate air molecules surrounding the glass, causing the glass itself to vibrate. This is known as resonance. The glass would need to have microscopic defects big enough to buckle under the pressure for the glass to shatter, though. The chances of finding such a glass are slim, particularly as the fractures cannot be seen by the naked eye. Furthermore, the note the singer hits must match the glass's resonant frequency.

Mint makes water taste colder because of menthol

Cold-sensitive nerves are coated in tiny pores known as TRPM8 receptors, which are usually firmly closed. When the temperature drops, the channels open, and positively charged ions flood into the nerve cell triggering an electrical signal that travels towards the brain. Although mint does not actually reduce the temperature of the mouth, it contains an ingredient called menthol, which can stick to the TRPM8 receptors. This makes the receptors more sensitive than before, meaning that if you drink a glass of cold water the channels will open more easily, making it feel colder.

The secret to popping candy is in the recipe

Popping candy explodes on the tip of your tongue, creating a fizzing sensation in the back of your throat. The secret to its unique fizz, crackle and pop is actually all down to how it is made.

In fact, popping candy is created in a similar way to traditional boiled sweets. Sugar, corn syrup, water and flavouring are all mixed together and then heated so that the water boils off. If the resulting sugar syrup solution would be left to cool at this stage, you'd end up with regular hard sweets. But in order to give the candy its unique popping potential, the molten mixture is exposed to high-pressure carbon dioxide gas at about 40 times atmospheric pressure. This causes small bubbles of gas to form within the solution. As this is then cooled, the pressure is released, causing the candy to shatter into small pieces of rock. However, each piece still contains tiny high-pressure bubbles. When you then place the candy on the tip of your tongue, and it begins to melt, the trapped pressurised bubbles are released, creating a unique sizzling sound and the sensation of it bursting and bouncing around your mouth.

Pop Rocks candy bounces in your mouth when high-pressure carbon dioxide bubbles are released as it melts on your tongue

DID YOU KNOW...

It's possible to 3D print a car

Being able to buy your own 3D-printed car from a factory nearby may soon become a reality with the Strati from Local Motors. Created using BAAM (big-area additive manufacturing), the world's first fully drivable 3D-printed car will be electric and have just 40 parts – significantly fewer than the 2,000 parts most vehicles include. Mechanical components such as the battery, motors, wiring and suspension are sourced from Renault's Twizy, an electric city car, while everything else on the Strati that could be integrated into a single material piece – including the frame, exterior body and some interior features – has been printed using ABS plastic reinforced with carbon fibre.

The two-seater design currently takes 44 hours to print, and Local Motors aims to be able to speed the process up to 24 hours without any reduction in build quality. The Strati's body is made up of approximately 212 layers laid down slice by slice; making the Italian word for layers, 'strati', an ideal name. Driving the car is an electric motor powered by a 6.1-kilowatt battery that can be recharged in a comparatively fast three-and-a-half hours and propel the Strati up to a top speed of about 80 kilometres (50 miles) per hour.

Local Motors is developing the car as an open-source project, allowing all digital 3D-print files and build manuals to be freely downloaded and even modified by individual users. With the company also intending to open 100 microfactories near major cities worldwide within the next ten years, the automotive industry certainly seems set for a 3D-printing revolution.

WHAT IS BIG-AREA ADDITIVE MANUFACTURING?

Similar to the process used by at-home desktop 3D printers, BAAM relies on a digital 3D model part becoming sliced into layers, which are then used to generate the real layers of ABS plastic that are created by the 3D printer when laying down the material slice by slice. Aside from the print size required, one of the major differences between a desktop 3D printer and the system used to create the Strati is the feed system.

The Local Motors team use a pellet feed as opposed to filament-fed extruders as feedstock is significantly cheaper than filament, making it easier to experiment with more material combinations.

This is a huge help with elements such as the durable carbon-fibre composite ABS used to print the Strati's components.

Carbon-fibre composite ABS may be difficult to find in filament form, but there are many new metallic filaments you can buy for use with a 3D printer

"Xen-source project, allowing all digital 3D-print files and build manuals to be freely do"

The 3D-printed Strati will reportedly go on sale in 2016, with cost likely to be in the range of £11,800-£19,700 ($18,000-$30,000)

DID YOU KNOW...

Riding the Wall of Death requires a good understanding of physics and a lot of bravery

Motorcyclists can defy gravity on the Wall of Death

The Wall of Death – also known as the motordrome or silodrome – is a barrel-shaped cylinder, usually made out of wood. Motorcyclists perform stunts while riding on the vertical wall.

The Wall of Death is a popular travelling carnival act dating from the early-20th century, but there are just a few left today. The motorcyclist starts at the bottom with the crowd looking down into the drum. After ascending a ramp to gain speed, they then begin circling the vertical wall, held in place by centripetal force. There are three forces working on the cyclist: gravity, the wall and friction. The cyclist must maintain a constant speed to keep the motorcycle's direction of motion constantly changing. They must also lean up at an angle (with respect to the wall) while riding to keep the bike's torque at zero.

This impressive feat occasionally results in accidents if the cyclist gets too close to the top of the wall or fails to maintain the speed or angle necessary to stay up.

One of the six formations is a three-hull 'trimaran'

The shape-shifting boat has six shapes

The Kormaran is set to make waves – both figurative and literal – in the boating industry.

By operating the hydraulic arms electronically, the driver is able to change the Kormaran into six configurations, including a three-hull 'trimaran'. This works by moving the outer hulls by differing amounts, altering the number of hulls in contact with the water. A hydrofoil formation is also possible, which results in extremely efficient travel thanks to an 80 per cent reduction in water resistance due to the hull not touching the water.

Measuring 6.4 metres (21 feet) long, it is built using quality materials such as carbon fibre, titanium and teak. The Kormaran's power comes from the 493-horsepower triple-jet drive, enabling it to reach a top speed of 70 kilometres (43 miles) per hour, at which it can travel for up to 200 kilometres (124 miles). As you would expect, this technology comes at a price. It is reported to cost around €1 million (£720,000 or $1,070,000) plus VAT, but the company will argue this is good value for money, as you effectively get six boats for the price of one.

One configuration transforms the Kormaran into a diving and sunbathing platform

DID YOU KNOW...

The AirBoard can get 1.5m off the ground

Ever wanted to fly but don't have the time or money to train as a pilot? The new AirBoard could be the answer. The smallest one-person aircraft in the world, it can carry the weight of a single person using its powerful battery. The AirBoard is classified as an ultralight quadcopter aircraft and it's small enough to fit in the boot of your car.

Its thrust is provided by four high-speed electric motors that each power a propeller. The drive system is managed by an Intel processor chip that incorporates a ground collision sensor to keep the board at a set height above the ground. This system comes into its own when you take the AirBoard into the great outdoors. Designed for both urban and rural use, the quadcopter will hover over nearly all ground, whether it's a snowy plain, water, rocky terrain or just in the street.

The device is easy to control, requiring the user to merely lean in the direction they want to go. For safety, the board's altitude is limited to a tame 1.5 metres (4.9 feet). The AirBoard's qualities make it ideal for recreational use but its features also make it potentially useful in search and rescue for the emergency services and perhaps even espionage for the military.

THE CONTENDERS

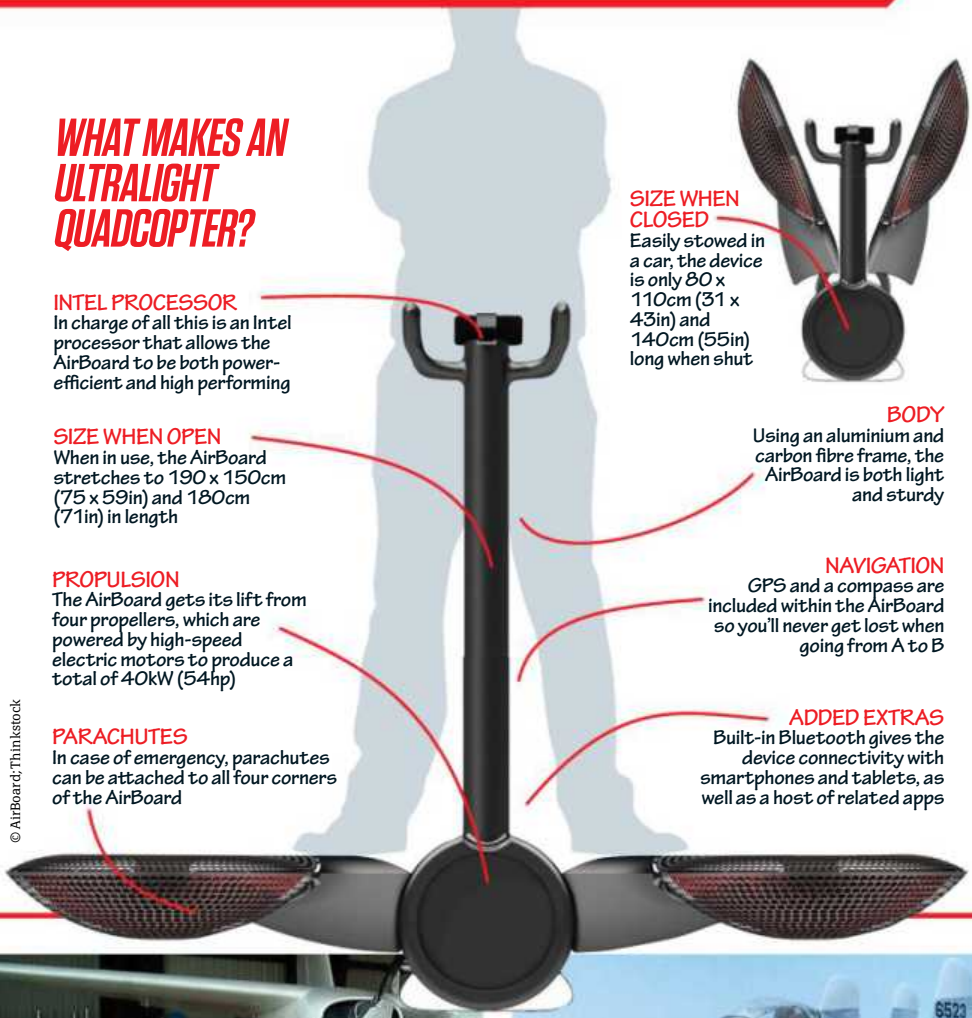
MESSERSCHMITT ME-328

It may have never made it past the prototype stage, but the Messerschmitt Me-328 is the smallest pulsejet fighter of all time. It would have been used by Nazi Germany as a parasite fighter launched off larger aircraft.

BUMBLE BEE II

The tiny 2.7m (8.8ft)-long Bumble Bee II, built by Robert H Starr, is listed by the Guinness Book Of Records as the smallest aircraft ever made. It took its first flight on 8 May 1988, but crashed due to engine failure on the same day.

WHAT MAKES AN ULTRALIGHT QUADCOPTER?



INTEL PROCESSOR
In charge of all this is an Intel processor that allows the AirBoard to be both power-efficient and high performing

SIZE WHEN OPEN
When in use, the AirBoard stretches to 190 x 150cm (75 x 59in) and 180cm (71in) in length

PROPULSION
The AirBoard gets its lift from four propellers, which are powered by high-speed electric motors to produce a total of 40kW (54hp)

PARACHUTES
In case of emergency, parachutes can be attached to all four corners of the AirBoard

SIZE WHEN CLOSED
Easily stowed in a car, the device is only 80 x 110cm (31 x 43in) and 140cm (55in) long when shut

BODY
Using an aluminium and carbon fibre frame, the AirBoard is both light and sturdy

NAVIGATION
GPS and a compass are included within the AirBoard so you'll never get lost when going from A to B

ADDED EXTRAS
Built-in Bluetooth gives the device connectivity with smartphones and tablets, as well as a host of related apps

BEDE BD-5

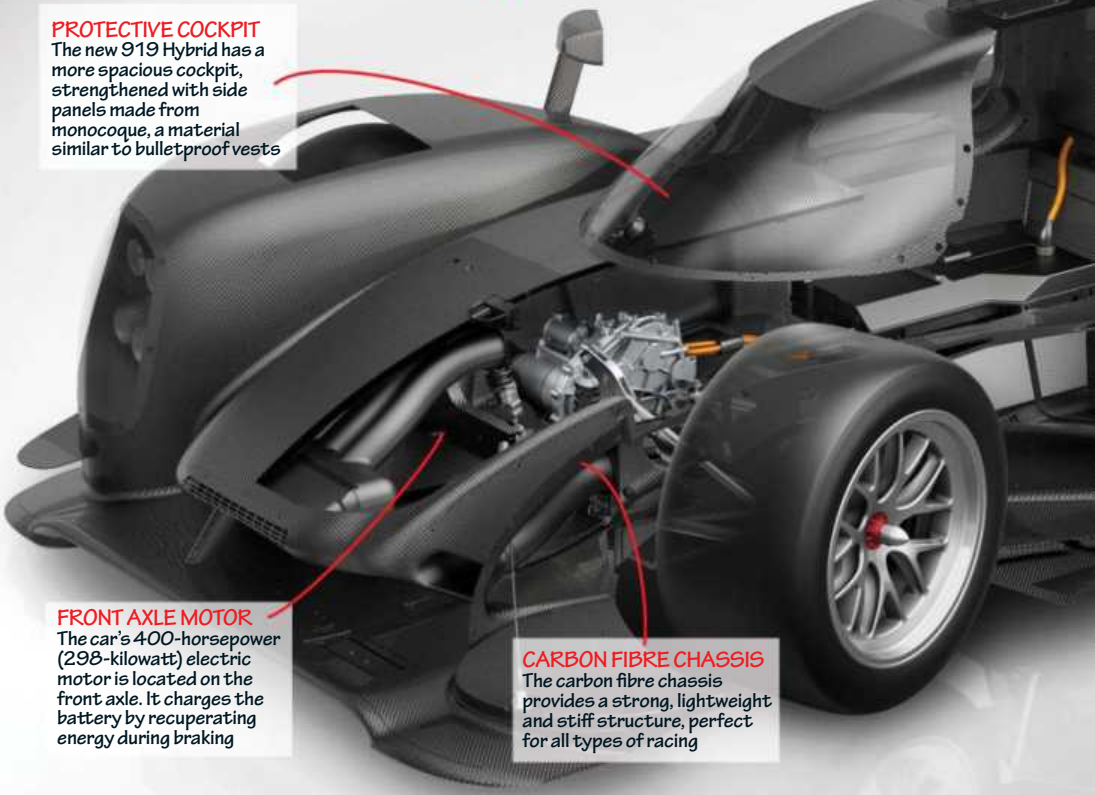
The Bede BD-5 is considered the smallest civilian jet but not the world's smallest aircraft. Its first flight was in 1971 and despite its 3.8m (12.5ft) length it can reach a top speed of 483km/h (300mph).

XF-85

A prototype parasite fighter like the Me-328, the American XF-85 Goblin was the world's smallest jet fighter. At 2,050kg (4,519lb) when loaded, it is significantly heavier than the civilian aircraft on the list, mainly due to its four machine guns.

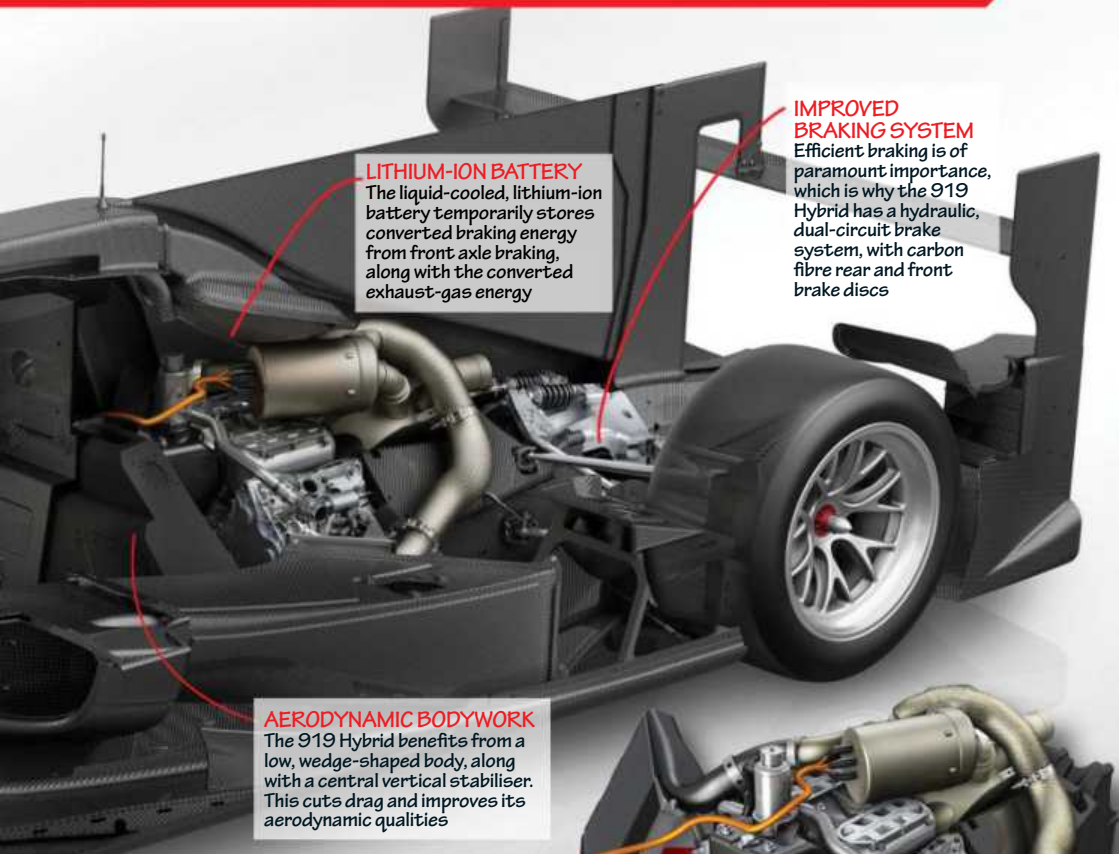
DID YOU KNOW...

The Porsche 919 Hybrid produces 500 horsepower



The 24 Hours of Le Mans is the oldest active endurance race in the world. It has been held every year since the inaugural race in 1923 and is often referred to as the 'Grand Prix of Endurance and Efficiency'. Keeping a car running for 24 hours is no mean feat; excellent fuel, tyre and braking efficiency is a must if you want to stay out of the pit lane. The race is also very demanding for the drivers. They form part of a team of three, often driving for two hours at a time, which challenges them both physically and mentally. During the 24 hours, the competitors will typically cover distances of over 5,000 kilometres (3,107 miles). The record distance of 5,410.71 kilometres (3,362.06 miles) was set in 2010, which is the equivalent of completing a Formula One race 18 times.

Porsche is the most successful manufacturer in the history of Le Mans. It's been the overall winner 17 times, however Audi, who has won 13 of the last 16 Le Mans, claims recent dominance of the test.



LITHIUM-ION BATTERY
The liquid-cooled, lithium-ion battery temporarily stores converted braking energy from front axle braking, along with the converted exhaust-gas energy

IMPROVED BRAKING SYSTEM
Efficient braking is of paramount importance, which is why the 919 Hybrid has a hydraulic, dual-circuit brake system, with carbon fibre rear and front brake discs

AERODYNAMIC BODYWORK
The 919 Hybrid benefits from a low, wedge-shaped body, along with a central vertical stabiliser. This cuts drag and improves its aerodynamic qualities

Porsche hadn't claimed the title since 1998, but rediscovered its winning formula in the redesigned 919 Hybrid. The 2015 Porsche 919 Hybrid was thoroughly tested, clocking an impressive 26,675 kilometres (16,575 miles) on four different race tracks. It features a vastly improved engine system; the electric motor's performance has been increased by a third, meaning the 919 Hybrid raced in the eight-megajoule category for the first time this year. Having become lighter, more robust and easier to handle, the designers managed to lead Porsche to their 17th Le Mans title, with Formula One's Nico Hülkenburg and Porsche factory driver Earl Bamber at the helm in their first ever Le Mans endurance test.

THE V4 PETROL ENGINE

At the heart of the 919 Hybrid is a turbocharged, gasoline-powered engine that sends power straight through to the car's rear wheels. It contains four cylinders, which work together to produce 500 horsepower (373 kilowatts) and revs at 9,000rpm – this is pretty impressive for a two litre engine. Also located here is the car's gearbox, along with a generator spun by the turbocharger. The engine is mainly made of aluminium, with magnesium and titanium incorporated within it, achieving an ideal weight for the car. Combined with the 919 Hybrid's two energy recuperation systems, it means that altogether the V4 makes for a very efficient race-car engine.

DID YOU KNOW...

Electric cars can be charged by the sun

Electric and hybrid cars are becoming much more of a common sight on the roads, with many plug-in charging stations now visible in car parks and service stations around the globe. However, there's a new technology now available that enables these cars to be charged without the need for a mains power supply, instead drawing on energy from the Sun.

This system of solar panel parking works by converting daylight energy into electric energy, trickle-charging cars ready for use. Photovoltaic panels mounted to the roof of the parking lot or carport absorb the Sun's rays and convert the solar energy into electric energy compatible with the automobile, which is fed in via an adaptor to the car's standard electric charging port.

However, while this can reduce costs of electricity charging at the mains, photovoltaic panels are not yet efficient enough to convert all the solar energy they receive into electricity, so several hours of solar charge won't power a car for a long period of time. The technology is in its infancy, though, and could well provide a framework for the future of regenerative-fuelled motoring.

This solar panel parking unit was installed at a parking lot in Portland, USA, in 2011 for electric cars to use

Jet skis work in accordance to Newton's third law

You probably know these high-powered machines as Jet Skis, but that's just a brand name. The real term is a personal watercraft (PWC) and they can hit speeds of over 100 kilometres (62 miles) per hour and churn out around 220 kilowatts (300 horsepower) of power as they zoom across the water.

Since a PWC weighs as much as five adults, the engine has to be really powerful. The engine tasked with reaching these speeds uses Newton's third law of motion, which states that for every action there is an equal and opposite reaction. A PWC works by sucking water through a grate at the bottom of the craft and shooting it out the back. This force pushing backward from the engine propels the craft forward. It's similar to when you're swimming front crawl, pulling back with your arms in order to keep moving. Rocket engines actually work based on the same principle, using hot gas instead of water.

DID YOU KNOW...

Solar Impulse 2 can take flight without fuel

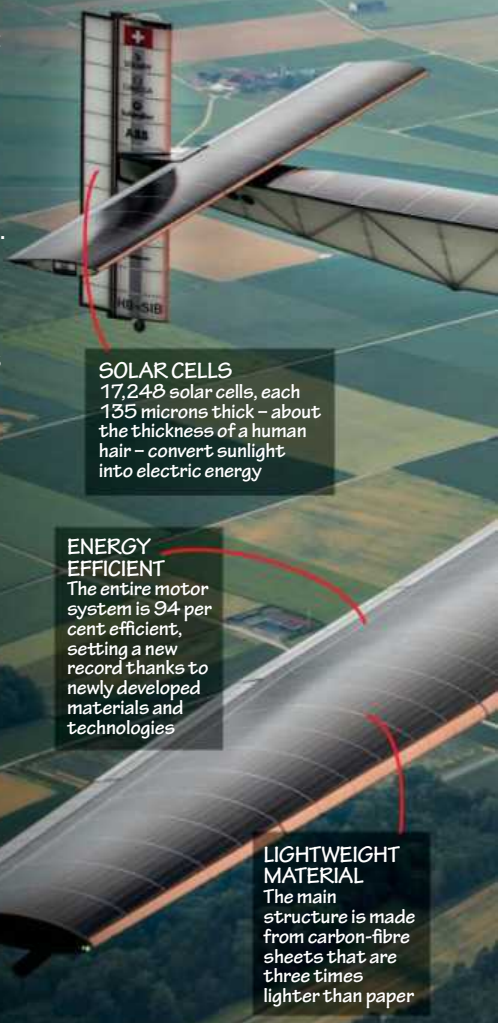
On 9 March 2015, the first-ever round-the-world flight powered only by solar energy took off. The Solar Impulse 2 started its mammoth journey in Abu Dhabi, with the aim of flying over oceans and continents before landing back where it started in a series of 12 legs, the longest at five days over the Atlantic and Pacific oceans. The whole flight was expected to take around 500 hours or just over 20 days, paced over 5 months.

Unfortunately, the flight over the Pacific caused irreparable damage to the batteries by over-heating. New batteries means more testing had to be carried out before it could continue on its flight, which started again in April 2016 and landed successfully back in Abu Dhabi in July 2016. It holds multiple World Records, one for the longest solar flight for both time and distance, and one for the longest solo flight by time.

Despite its unlimited energy supply, it is the pilot's need for rest and a limited space for food supplies that enforces stops. Taking turns at the controls will be Solar Impulse chairman Bertrand Piccard and cofounder and CEO André Borschberg.

It works by turning sunlight into electric energy using the solar cells stretched across its enormous 72-metre (236-foot) wingspan. The whole aircraft weighs only 2,300 kilograms (5,071 pounds) helping it climb to a maximum altitude of 8,500 metres (27,890 feet). At night it will drop to 1,500 metres (4,920 feet) to conserve as much of the energy stored in the four batteries as possible. To avoid turbulence and winds of more than seven knots (13 kilometres [eight miles] per hour), all takeoffs and landings will be scheduled at night.

POWERING THE SOLAR IMPULSE 2



SOLAR CELLS
17,248 solar cells, each 135 microns thick – about the thickness of a human hair – convert sunlight into electric energy

ENERGY EFFICIENT
The entire motor system is 94 per cent efficient, setting a new record thanks to newly developed materials and technologies

LIGHTWEIGHT MATERIAL
The main structure is made from carbon-fibre sheets that are three times lighter than paper

72-HOUR FLIGHT SIMULATION

Both pilots have completed 72-hour stints in a flight simulator, recreating the cockpit conditions. This enabled them to test and evaluate their nutrition plan, toilet facilities and exercise regime to prevent deep vein thrombosis. They could also try out their rest strategy, which uses relaxation techniques for the shorter flights and taking 15 to 20-minute micro-naps for the longer stretches.

STORING ENERGY

The batteries can store 260Wh/kg and can be fully charged in just 3-4 hours when the aircraft is grounded

MAXIMUM SPEED

The aircraft has maximum power of 70hp (52.2kW) and can reach speeds of up to 140km/h (87mph) at maximum altitude

CREATING THRUST

The four motors each generate 17.5hp (13kW) of power, rotating the 4m (13.1ft)-diameter propellers to create thrust

BATTERY POWERED

Energy is stored in four lithium polymer batteries, which weigh 633kg (1,396lb) – over a quarter of the aircraft's total weight

This illustration shows the pilot's resting position in the Solar Impulse 2's cockpit

INSIDE THE COCKPIT

The 3.8-square-metre (40.9-square-foot) cockpit will be each pilot's home for up to five days at a time. It can store the 2.4 kilograms (5.3 pounds) of food, 2.5 litres (0.7 gallons) of water and one litre (0.3 gallons) of sports drinks they will need each day, plus enough oxygen to survive in the unpressurised cockpit. Temperatures will fluctuate between +40 and -40 degrees Celsius (-40 degrees Fahrenheit) while in the air, so the cockpit is insulated with isolation foam, and the pilot's clothing contains intelligent nylon fibres to stabilise their body temperature. The seat contains the toilet, parachute and life raft, plus it can lie flat to allow the pilot to stretch their legs. A matchbox-sized electrocardiogram will monitor the pilot's fatigue and vigilance and a tailor-made autopilot system will monitor the aeroplane. They will also have a vibration device fitted into their sleeves to alert them to any problems or anomalies.

DID YOU KNOW...

The amazing Martin Jetpack can fly for 30 minutes

Ever since they first made an appearance in science fiction films, real jetpacks have been promised by a number of different companies and inventors around the world. With its latest prototype, the Martin Aircraft Company believes it has mastered this long anticipated personal aircraft.

Despite the name, it isn't actually powered by a jet engine. Instead, this contraption relies on a 200 horsepower, V4 engine, fuelled by a mix of regular petrol and two stroke oil – much like old mopeds. This powers two carbon fibre fan ducts, one fitted to either side of the jetpack. Air is drawn in from above and accelerated using the fan's rotors, creating enough downforce to propel a payload of up to 120 kilograms to a height of around 900 metres.

The aircraft is made from sturdy, foam-filled carbon fibre, and can be piloted using two joysticks and a touchscreen, or flown from the ground via a remote control. It benefits from a fly-by-wire, semi-automatic system that helps to balance out the controls between the pilot and the onboard computer. Once airborne, the Martin Jetpack can fly for roughly 30 minutes, achieving a top speed of 74kmph.

When this jetpack does eventually go on sale, it will retail in the region of £99,000 ($150,000). However, this won't just be reserved for gadget-loving millionaires. A number of emergency services are interested in using the jetpack; the Abu Dhabi fire service has already made a bulk order.

JETPACK ANATOMY

BUILT-IN SAFETY
The parachute system automatically deploys if the engine fails, allowing the aircraft to slowly return to the ground

CARBON STRUCTURE
The jetpack's central beam is made from carbon fibre with a foam core, while the fuel tank is encased in Kevlar and a fuel-resistant resin

PILOT PROTECTION
The roll bar and arm restraints help to keep the pilot safe; the aircraft's structure adds additional protection from the rear and sides

POWERFUL ENGINE
The 200 horsepower, petrol-powered engine provides a top speed of 74 kilometres per hour

TAKING OFF
The aircraft takes off and lands vertically, much like a helicopter

DID YOU KNOW...

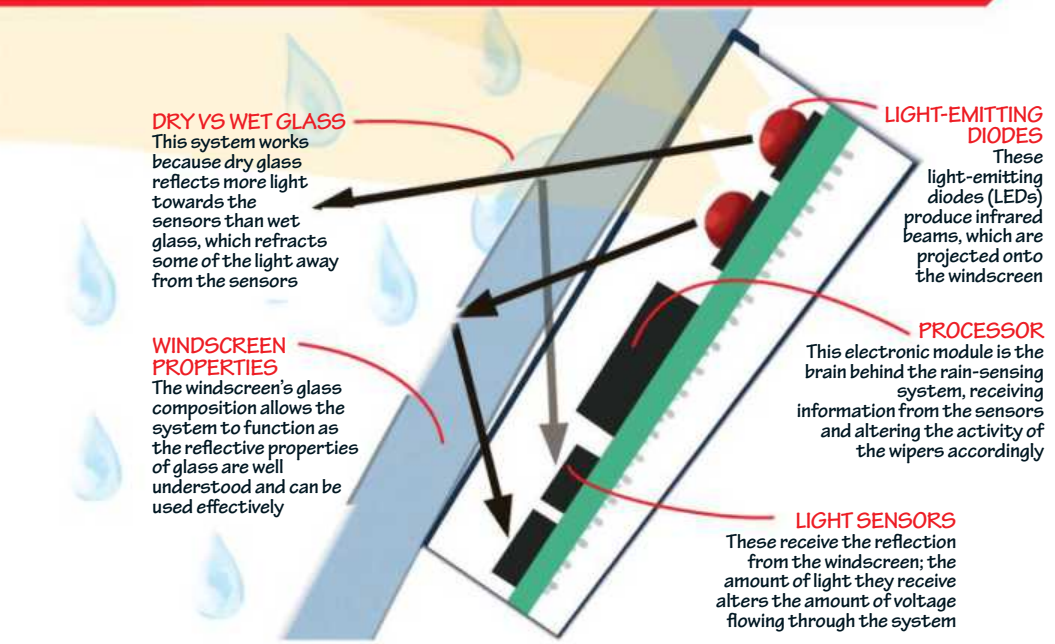
The Air Wheel can travel up to 45km without being charged

The brand new AirWheel – a self-balancing unicycle – could really liven up your daily commute. By simply leaning in the desired direction, you will be transported to wherever you want to go with the minimum of fuss. The AirWheel incorporates a fast-charging battery, like the ones used in the latest eco-friendly cars, and cutting-edge gyro technology that helps maintain its self-standing orientation.

On the most advanced model, a single charge will last for up to 45 kilometres (28 miles) and when the battery is spent it will gently lean back rather than cutting out sharply. Better still, when you go downhill or slow down, the battery will start to regenerate some of its lost juice.

Waterproof and made of a comfortable elastic silicone, the AirWheel has been ideally designed whether it's for your nine-to-five or a quick jaunt down the shops. Even stairs don't faze the device, with a built-in carry handle that can be safely stowed away when not in use.

The AirWheel is priced between £509.99 and £799 ($849 and $1,333) and comes in six different unicycle models



In the future cars will have force fields

The intermittent windscreen wiper system has undergone much refinement since its first appearance in a 1970 Citroën SM. Although it may seem simple to flick a switch and turn on your wipers manually, automatic wipers have the advantage of reducing distraction and improving visibility. A popular automatic system uses invisible infrared light which is projected across the windscreen and reflected back toward an array of sensors. When rain hits the windscreen, the water droplets refract the light so less of it bounces back toward the sensors. The sensor, typically located on the back of your rearview mirror, detects these changes in the amount of light received. Software will then determine the required wiper speed depending on how much light is refracted by the water.

McLaren has reportedly been developing technology that will consign the windscreen wiper to history. By using ultrasound, its device effectively creates a force field over the windscreen, stopping water from staying on the glass. Whether this will be as efficient as full-speed wipers during a heavy downpour is yet to be seen.

The humble windscreen wiper has some clever technology powering it

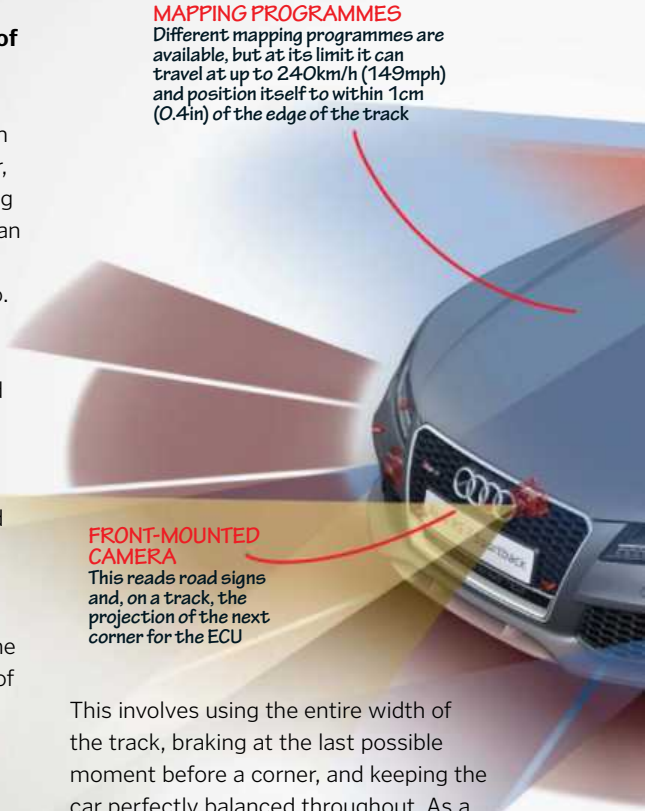
DID YOU KNOW...

An Audi RS7 can go faster without a driver

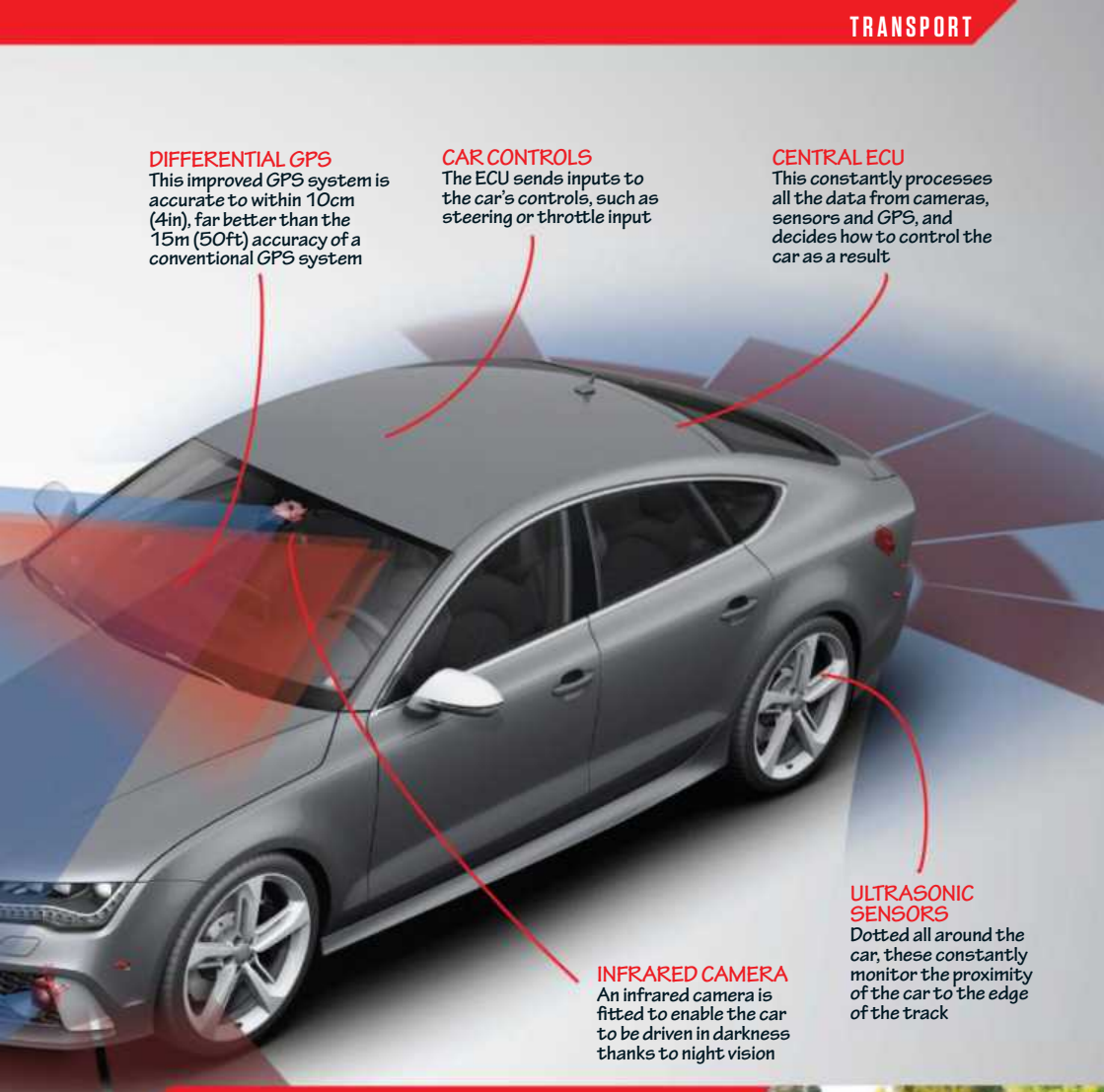
It's the age-old debate: is technology better than the talents of humans? In the automotive world, this argument is fast rearing to a head, with driverless cars now being fully tested on public roads around the world. However, while driverless cars are primarily aiming to be safer than those piloted by a human being, German manufacturer Audi wanted to find out if they are faster, too. The answer to this is the Audi RS7 driverless car prototype, a pumped-up sports car that's been specially adapted with driverless technology.

The RS7 driverless concept works in much the same way as a conventional driverless car currently being developed by other manufacturers, including Toyota and Google. As well as an advanced GPS system with pinpoint accuracy, cameras are placed around the vehicle that 'read' signs and the layout of the road or track ahead. These work in tandem with sensors and radars dotted around the vehicle, which constantly monitor the proximity of the car to the road and other objects. All this information is fed to a central computer, which processes the information and operates the car accordingly.

Where the Audi RS7 triumphs over other driverless cars, though, is not only in the speediness of this entire process, but also in its intelligence. On a track, a 'racing line' is taken by drivers to get around the track in the quickest time.



This involves using the entire width of the track, braking at the last possible moment before a corner, and keeping the car perfectly balanced throughout. As a thrash around the Hockenheim circuit demonstrated, the driverless RS7 prototype was found to take a very precise racing line on the track, nearly identical to that of a seasoned racing driver. The technology isn't without merit, either: a driverless RS7 actually beat a lap time around the Ascari circuit (by two whole seconds) set by a human being in an identical car.



THE EVOLUTION OF THE DRIVERLESS CAR

The driverless car industry is fast evolving within the automotive industry. Interestingly, it's not car manufacturers themselves that are at the forefront of the technology either: that accolade goes to technology giant Google, which has developed a unique pod-like vehicle. Materials used on the Google car are also ground-breaking, with a bendy facia and plastic windscreen implemented to help cushion the blow to a human in the unlikely event of a collision.

Other companies such as Toyota or Volvo have been busy adapting their own conventional passenger vehicles to accommodate driverless tech, but the roof-mounted radar and bigger computers have often proved unsightly and impractical. But there's more: rumours are also gathering pace that Apple is developing its own autonomous vehicle, so watch this space...

DID YOU KNOW...

Smart helmets can predict accidents

Cyclists have long worn helmets to protect their head in the event of a collision. Now though, Swedish automotive manufacturer Volvo has created a pioneering new smart helmet that not only protects the cyclist, but also warns them of potential accidents. The helmet is part of a two-way system where both cyclists and drivers continuously upload their location to a cloud system. The system can then warn the respective parties as to the proximity or direction of oncoming objects that interferes with their own location and trajectory.

For cars, these warnings are conveyed via warning lights on a heads-up display system in front of the driver on their windshield, which is particularly useful for when a cyclist is in a vehicle's blind spot. For cyclists, these warning lights are built into an otherwise ordinary-looking helmet, which pulse from its beak. This ensures the cyclist is alerted to the impeding danger with enough time to take evasive action, without the lights impairing the vision of the cyclist.

While this is a great idea in principle, there are limitations to this early stage of technology. First, not everybody drives a Volvo, and second, many people will feel uncomfortable uploading their current location to a cloud sharing service.

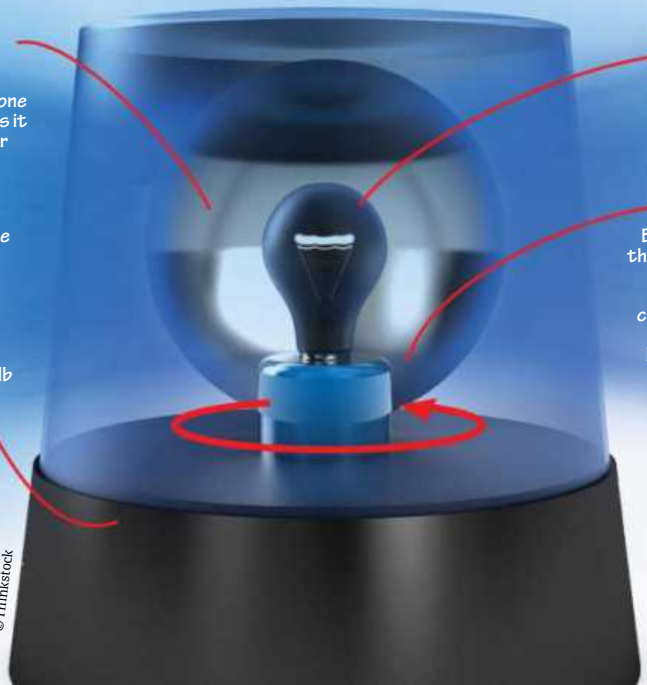
Emergency vehicle lights don't flash

Reflectors rotate in order to product a flashing illusion

Fixed to the top of service vehicles, flashing blue lights are deployed in the event of an emergency. Their bright flashes grab the attention of other road users from a distance, allowing them to take evasive steps in good time to make sure the emergency vehicle can pass through safely and quickly, even in heavy traffic, which is crucial when responding to an emergency call.

Although brighter, more efficient blue LED lights are now commonplace on police cars, ambulances and fire engines, the old-fashioned method of using a see-through unit with a single light bulb inside has long been a trusted ally of the emergency services – and its magic is in the illusion it creates.

Of course, bulbs can't keep flashing on and off for long periods or they'll blow, so the illusion is created by a rotating base with a vertical reflector affixed to it, moving around a fixed light bulb. The reflector redirects light outward from one side, while blocking the light out to the other. When the base is rotated fast, this creates the 'on-off' illusion of a flashing blue light atop an emergency vehicle.



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DID YOU KNOW...

MULTI-SURFACE
The gloves can stick to any smooth surface including glass, plastic panels, painted or varnished wood panels and metal

SPRING-LOADED
The pads are connected to special springs that become less stiff the further they are stretched When the springs are released, the wedges revert back to an upright position, reducing the surface area and the attractive force

ADHESIVE TILES
Each glove is covered with 24 stamp-sized adhesive tiles, which are covered with slanted microwedges made of polymer

MICROWEDGES
Each wedge is just 100 micrometers long (roughly the diameter of human hair). When a force is applied, the microwedges bend over, causing a larger surface area to come into contact with the wall

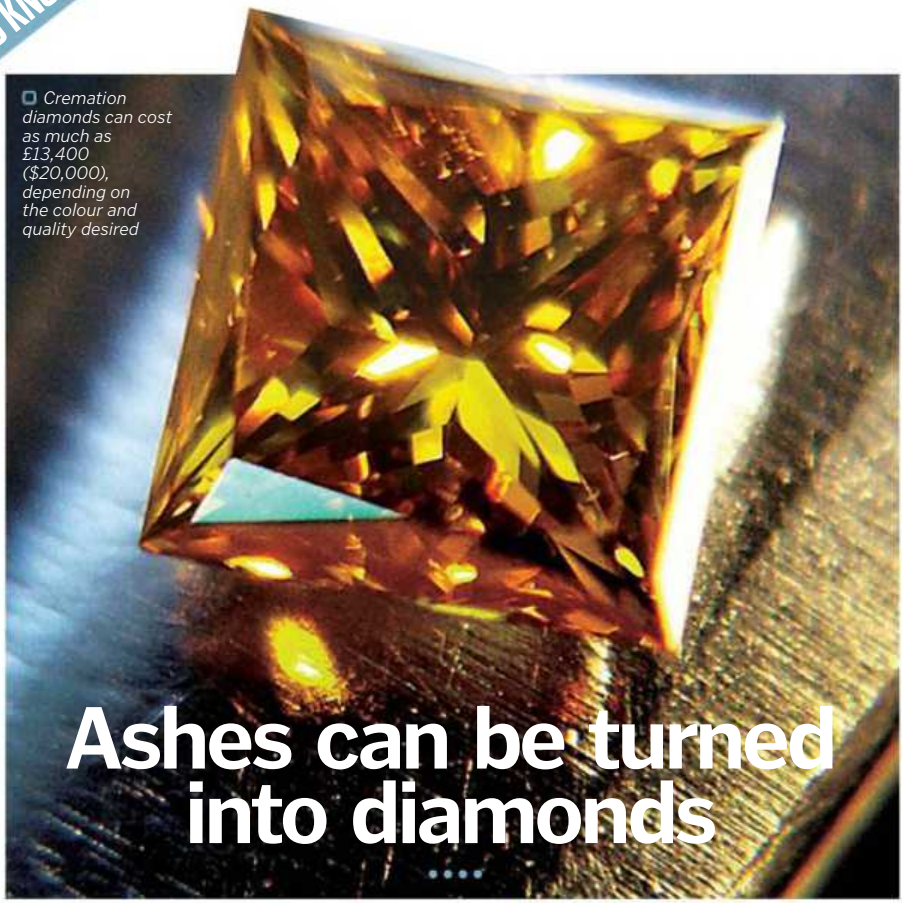
Adhesive gloves make it possible to climb walls

Being able to scale skyscrapers like everyone's favourite web-slinging hero would make your morning commute more fun, but the secret to harnessing this power comes from geckos rather than spiders. Students at Stanford University have created special dry adhesive gloves that imitate the microscopic hairs found on a gecko's feet, enabling humans to implement the same scientific sticking principle they do. However, a gecko only weighs a few grams, so they had to come up with a clever solution to allow for the extra weight. This came in the form of special springs, which help to spread weight evenly across the gloves, providing sufficient adhesion to support up to 91 kilograms (200 pounds). Humans don't have the incredible upper-body strength of geckos, though, so a bit of extra help is required in the form of moveable rope ladders. Initial tests of the gloves have proven successful, and now the students are working with NASA's Jet Propulsion Lab to see if similar technology can be applied to the robotic arms of spacecraft to catch space debris.

GET YOUR SPIDER-SENSE TINGLING

The ability to predict an oncoming obstacle or villain is important for any superhero, but we mere mortals have just created a suit that can help us do the same. It may not look quite as slick as Spider-Man's skin-tight ensemble, but the Spider-sense suit can alert you to any person or object within a 152-centimetre (60-inch) radius, even if you're blindfolded. It contains several sensor modules, each containing a range finder and a servo motor. The range finder continually emits a sonar pulse that bounces off of any nearby obstacles, enabling a sensor to calculate its distance from you. When an obstacle is detected, the servo motor activates an arm that applies pressure on your skin. The closer you get to the obstacle, the more pressure the arm applies, allowing you to judge its proximity and act accordingly. Inventor Victor Mateevitsi hopes the tech can help the visually impaired and those in low-visibility situations, such as firefighters entering smoke-filled buildings, to navigate safely.

Sensors spread across your body can alert you to an oncoming obstacle in a matter of milliseconds



Cremation diamonds can cost as much as £13,400 ($20,000), depending on the colour and quality desired

Ashes can be turned into diamonds

Knowing how to commemorate a loved one's passing is incredibly difficult for us all, but there is now a wide range of alternatives to traditional burial or cremation. An alternative to sending your relatives' ashes into orbit, a technique has been devised to convert them into diamonds. A typical 80-kilogram (176-pound) man produces enough ashes to make a 0.2-gram (0.007-ounce) diamond, as our bodies are 18 per cent carbon.

To do this, the ashes are heated to over 2,760 degrees Celsius (5,000 degrees Fahrenheit) in a heat-proof crucible. This works to oxidise all of the elements within the ashes, other than the carbon. The carbon is then heated for a number of weeks to turn it into graphite, which is then pressed with a metal catalyst and a diamond-seed crystal. This step requires temperatures of around 1,371 degrees Celsius (2,500 degrees Fahrenheit), along with extremely high pressures, and needs several weeks to convert the graphite into a rough crystal. This crystal can then be cut to specification and presented as desired. The finished diamond's colour is typically yellow or orange, depending on the amount of other trace elements within the original ashes. This can be changed by further enhancement techniques.

One application of the Splash nanosolution will make your phone water resistant for up to 12 months

Nanotechnology can make your phone water resistant

Accidentally spilling a glass of water over your phone can cause irreversible damage to the device. Of course, you could attach a waterproof case to make sure it is fully protected, but these often add a lot of bulk to your otherwise slim and sleek phone. However, now you can simply spray on an invisible water-resistant coating that is 1,000 times thinner than a human hair. Splash spray uses nanotechnology to create a small barrier of air around the phone to repel water molecules away from the surface and prevent them from getting inside. All you have to do is spray the openings and buttons on your phone and repeat the process three times, then spray a microfibre cloth and use it to buff the front, back and sides to remove any residue. The spray dries in ten minutes and makes your phone water resistant straight away. It will only protect your phone from spillages, though. Fully submerging your device will still allow liquid to enter the housing, causing damage to the elements inside.

DID YOU KNOW...

The Lytro Illum camera is available now for £1,299.99 ($1,599)

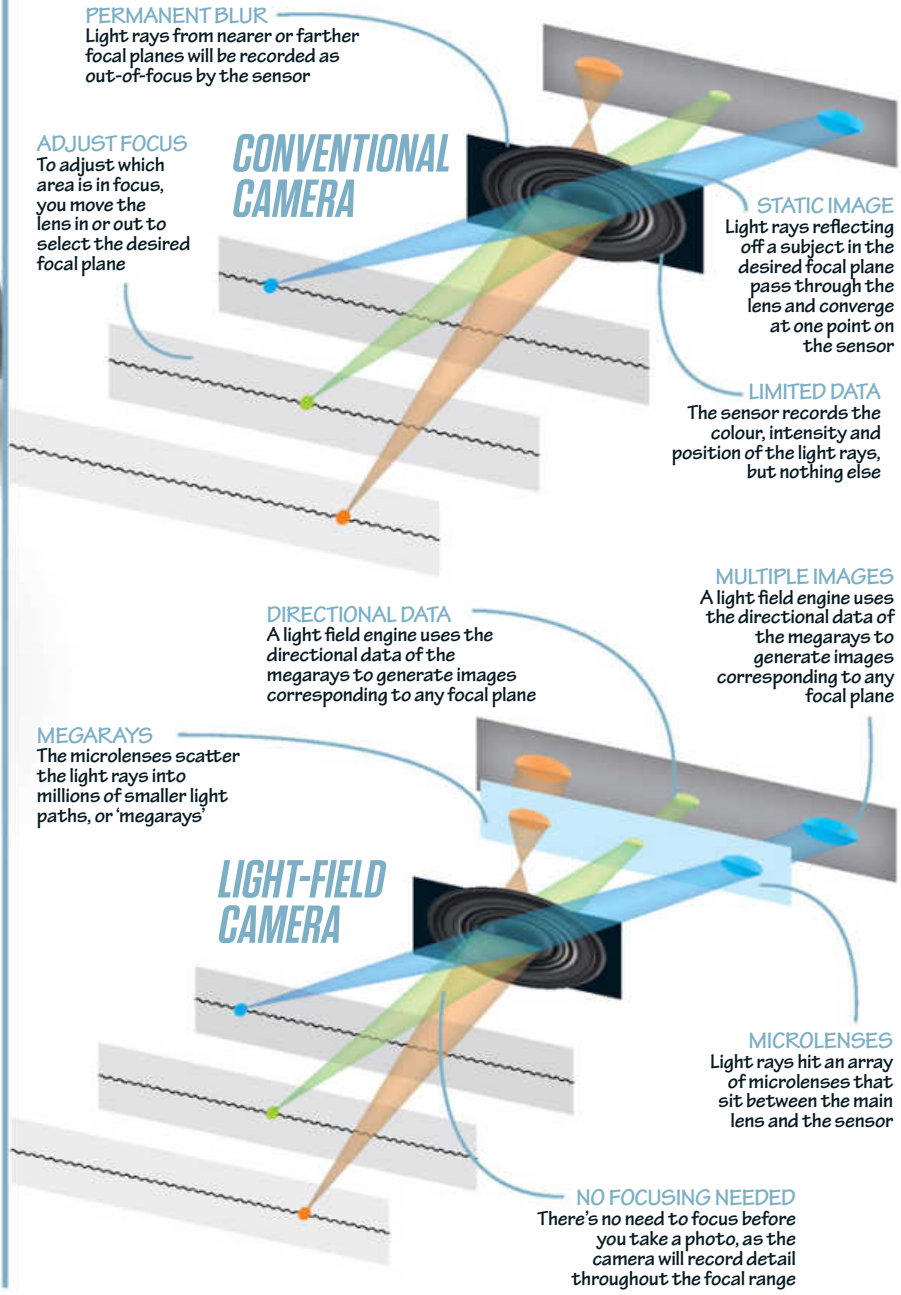
There is a camera that takes photos first and focuses later

Taking a photo only to discover your main subject is out of focus is a common and frustrating problem. It's okay if you can simply take the photo again, but what you don't notice the issue until you get home?

If you own a Lytro camera, you'll never experience this heartache again. Clever light field technology means you can refocus your photos – and even change the perspective – after you've taken them. It does this by using a microlens array and a special light field sensor to determine from which direction rays of light enter the camera. This allows it to record a multidimensional light field, which is passed through special software.

Complex algorithms are then able to simulate what the image would look like if you had focused on a different focal plane or taken it from a different angle and all of these possibilities are pieced together to create one adjustable image. Light field technology isn't new, but Lytro is the first to use it in a commercial camera. Its latest model is the Illum, which has an 8x optical zoom lens, ten-centimetre (four-inch) LCD screen and can shoot 3D images too.

CAPTURING LIGHT FIELDS



DID YOU KNOW...

Siri can be programmed to know who is in your family

Siri won't automatically know who you are. It's clever, but it's not that clever. You have to tell it who you are first, but you only need to do this once, and it stores the details. Go into Settings and then select Siri from the list. Scroll down to My Info and then enter your details. When you next talk to Siri, it should address you by name. It also uses your personal information to tailor answers to your circumstances. For example, if you ask what the weather is like, it will give you the local forecast.

Talk to Siri and it will talk back, using your name

Early typewriters used lots of different key layouts until QWERTY eventually took over

QWERTY is more efficient to type with

That's because it's less efficient. An alphabetical keyboard would put A and E on the left and middle of the top row, and T on the left of the bottom row. These are the most uncomfortable places for touch typists to reach, for some of the most common letters in English. The alphabet is a random sequence of letters and there's no reason to suppose it has an advantage for keyboards. There are patterns that are theoretically more efficient than QWERTY. These layouts never took off, but alphabetic order is demonstrably worse than QWERTY.

This scanning electron microscope image shows superglue's adhesive surface close up

Water creates super-strong superglue bonds

The compound responsible for superglue's characteristic sticky strength is called cyanoacrylate, which is an example of an acrylic resin. As soon as it is placed on a surface it cures (forms its strongest bond) in an almost instantaneous reaction, requiring only the presence of the hydroxyl ions found in water for this to happen. Nearly all surfaces we encounter have trace amounts of water, as it is present in the air we breathe. This process is an example of anionic polymerisation; the cyanoacrylate molecules link together in a mesh when they come into contact with water, creating a super-strong bond. This differs from the way white glues bond which is by solvent evaporation.

Other than sticking two materials together, superglue can be employed in a variety of other settings. In forensic science, it can be used to visualise latent (invisible) fingerprints, as the superglue's vapours bind to the moisture that is deposited by the fingerprint, turning them white and visible. This reaction also stabilises the fingerprint's detail, making it possible for further enhancement to be carried out. A non-toxic version of superglue has also been created for surgery which can be used to seal the skin without the need for sutures.

DID YOU KNOW...

Stephen Hawking's wheelchair is controlled with one button

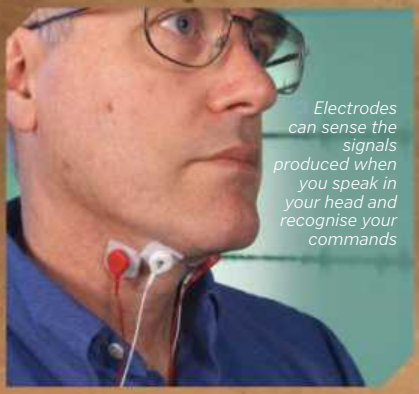
Stephen Hawking was diagnosed with amyotrophic lateral sclerosis (ALS) when he was 21. ALS is a form of motor neurone disease, which results in the progressive death of the nerves that control the muscles. Most sufferers die within five years, but fortunately for physics, and for Professor Hawking himself, his disease has progressed extremely slowly. Even so, at the age of 73, Hawking has just a small amount of motor function left, mainly in the muscles of his face. His link to the world is provided by the computer technology built into his wheelchair.

Professor Hawking controls all the functions of his tablet PC using just a single switch – imagine operating your PC using nothing but the spacebar. Hawking's PC uses a special interface called EZ Keys, which scans across each letter of the on-screen keyboard, one at a time. When Hawking moves his cheek, a sensor detects the movement and the computer halts the scanner and picks that letter. He can also use this process to scan from one button or menu item to the next, and so control his email program (Eudora), web browser (Firefox) or even make calls over Skype.

As Hawking's physical condition gradually deteriorates, his typing speed has dropped to just one or two words per minute. Scientists at Intel compensate using algorithms tailored to Hawking's vocabulary and writing style, which accurately predict which words he will want to use next.

THOUGHT-CONTROLLED WHEELCHAIRS

When you speak, your brain sends nerve signals to your throat, even if your muscles aren't strong enough to actually make audible sounds. In fact, this subvocal speech happens even if you just think the words in your head. Technology originally developed at NASA Ames Research Center is now available as a way for severely disabled people to control a motorised wheelchair or send their thoughts to a speech synthesiser. The user wears electrodes stuck to the skin of their throat and simply thinks command words such as 'go left' or 'stop'. The tiny electrical impulses are detected and decoded and the right command is sent to the wheelchair. Hawking has tried brain interfaces like this but they are still too inconsistent for him. At the moment, slight shifts in the placement of the electrodes can see the recognition rate drop from 94 per cent to less than 50 per cent.



Electrodes can sense the signals produced when you speak in your head and recognise your commands

CHAIR OF PHYSICS

IR SENSOR
A tiny infrared sensor mounted on his glasses detects when Hawking moves his cheek muscle

12" DISPLAY
The daylight-readable screen allows Professor Hawking to compose lectures, check his email and even use Skype

TABLET COMPUTER
A Lenovo ThinkPad X230t with a Core i7 processor controls all the systems on the chair

UNIVERSAL REMOTE
An infrared remote can operate TV, music, lights and even the doors, both at work and at home

SPEECH SYNTHESISER
A hardware synthesiser on the back of the chair translates written text into Hawking's distinctive electronic voice

"We're all pretty disabled on the cosmic scale. What difference is a few muscles more or less?"
– STEPHEN HAWKING

POWER
The computer system takes power from the wheelchair batteries under the seat and has its own backup battery too

PERIPHERAL BOX
Contains a USB hub, audio amplifier and voltage regulators for the different subsystems

DID YOU KNOW...

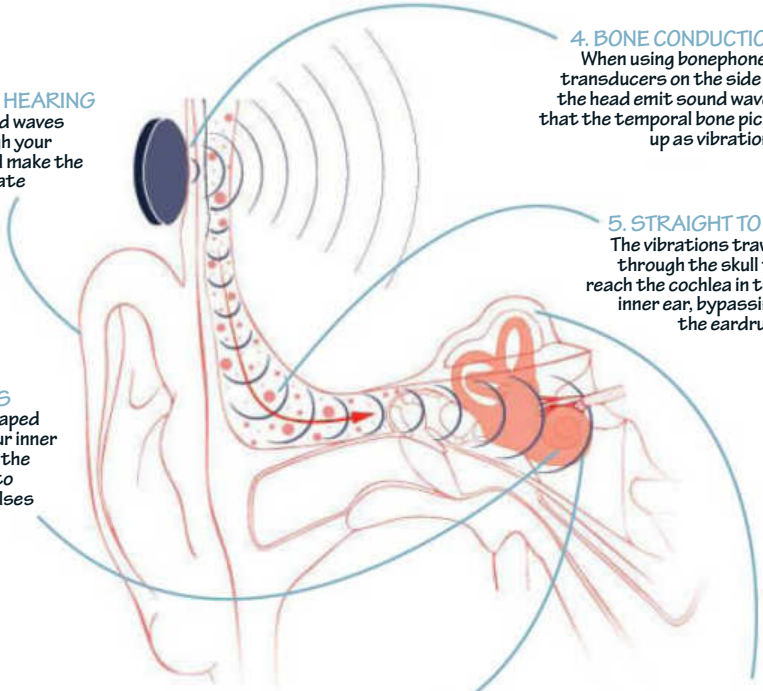
You can listen to music through your skull

One major flaw with regular headphones is that you can't hear anything but the music being blasted into your ears. While this might be a blessing when sitting on a crowded train or bus, it also means that you won't hear a car come speeding towards you if you step into the road. Bone conduction offers a clever solution, sending the music straight to your inner ear so your outer ear remains free to pick up sounds from your surroundings.

The futuristic looking Batband is a device that uses this bone conducting technology. Its spring steel frame grips around the back of your head and can be paired with your smartphone or music player via Bluetooth. When you play music, three transducers – two on the sides of your head and one at the back – emit sound waves that vibrate through your skull to be picked up by your inner ear. Although 'bonephones' are nothing new, Batband is the first to be completely ear-free. It also features a microphone that can be used to make phone calls, and touch sensors on the sides allow you to adjust the volume or skip tracks with a simple tap or a swipe.

Batband's touch sensors allow you to control it with simple hand gestures

HOW BONEPHONES WORK



1. NORMAL HEARING
Usually, sound waves travel through your outer ear and make the eardrum vibrate

2. GOOD VIBRATIONS
The spiral-shaped cochlea in your inner ear converts the vibrations into electric impulses

3. TO THE BRAIN
The electrical impulses travel along the auditory nerve to the brain, which recognizes them as sound

4. BONE CONDUCTION
When using bonephones, transducers on the side of the head emit sound waves that the temporal bone picks up as vibrations

5. STRAIGHT TO IT
The vibrations travel through the skull to reach the cochlea in the inner ear, bypassing the eardrum

6. EASY LISTENING
The normal hearing process resumes as the cochlea transforms vibrations into impulses, which are sent to the brain

HOW IT WAS DISCOVERED

It may seem cutting-edge, but bone conduction was first discovered in the 16th century when sound was transmitted to the inner ear by way of a metal rod held between the teeth. At the time, it was believed that the sound was travelling through the Eustachian tube, which connects the middle ear to the throat and nasal cavity, but around 100 years later it was discovered that the skull was actually transmitting the vibrations.

As well as helping to diagnose hearing disorders, bone conduction tests also led to the development of the tuning fork in 1711 and even helped Ludwig van Beethoven. The famous 18th century composer was almost completely deaf, and so attached a metal rod to his piano and bit down on it as he played, sending the sound vibrations through his jawbone and straight to his inner ear. However, it wasn't until the 20th century that bone conduction was used to develop hearing aids.

Beethoven used bone conduction to help him hear his own music

DID YOU KNOW...

You can keep tabs on your pets from work

Approximately 40 per cent of UK households have pets, and with more of us leading busy lifestyles, it's not always possible to give our animal pals as much attention as we, and they, would like. Thanks to technology, we can keep an eye on our pets and make sure they're entertained. From automatic ball launchers to Wi-Fi treat dispensers, there are many gadgets on the market to keep our pets happy and healthy. Gadgets that feature internet access via Wi-Fi or mobile networks provide owners with the ability to check in on and interact with their pets via phone.

PETZI

This camera enables you to keep an eye on your pet using the accompanying smartphone app. The wide-angle lens provides you with a fantastic view of your furry friend, and treats can even be launched from the unit at the simple touch of a button.

WHISTLE ACTIVITY MONITOR

A fitness tracker for your dog, Whistle helps keep track of your pet's activity levels and health. Attaching the small disc to your dog's collar enables you to monitor their daily activity through the Whistle app on your phone.

SHRU

This egg-like toy can help to keep your cat active and entertained all day long. Designed to look and act like a feline's prey, it autonomously darts around, keeping your kitty on its toes (or paws). You can also modify the Shru's behaviour by connecting the gadget to your own computer via USB.

HOW THE IFETCH WORKS

THE PERFECT TOY FOR YOUR POOCH TO PLAY WITH WHEN YOU'RE AWAY

ON-DEMAND PLAY
The device powers on automatically when a ball is dropped into the funnel, and goes into power-saving mode after launch

HOURS OF FUN
On a fully charged set of batteries, the iFetch can keep throwing balls for around 30 hours – enough to tire out even the most playful of puppies and dogs

GO LONG!
The iFetch's shooting distance can be adjusted to three, six or nine metres, depending on how much space you have

LAUNCH SYSTEM
Rapidly spinning wheels within the iFetch can accelerate the balls and shoot them out of the funnel

iFetch

GOBONE

A treat-filled plastic bone on wheels that moves around to encourage your dog to play. It provides mental and physical stimulation as pups chase, chew, squeak and eat food from it for up to eight hours per charge.

PETCHATZ

This interactive system connects to your home Wi-Fi network, so you are able to hold video calls with your pets through the companion app. The wall unit can also dispense treats, and a special PawCall button on the floor even means that your pet can call you.

DID YOU KNOW...

The Wimbledon roof spans 5,200 square metres

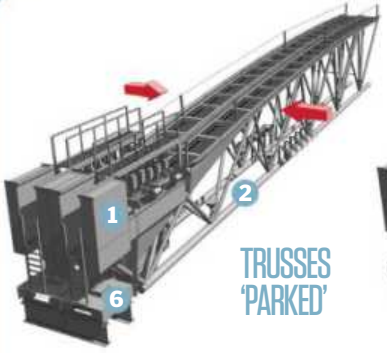
Tennis is a sport that requires good weather, so it's surprising that one of its premier competitions has been held in rainy England since 1877. So after 132 years, a roof was built on Wimbledon's Centre Court for the 2009 Championships. The primary function is to keep water off of Centre Court so games can continue when a downpour begins, but it also means games can continue after dark.

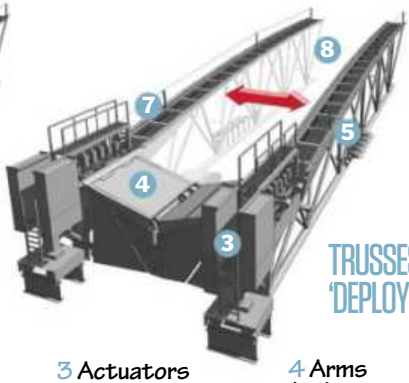
The roof spans 5,200 square metres (56,000 square feet) and is made up of a membrane held up by ten steel trusses, each weighing around 70 tons.

It only takes around eight minutes to close but the lights and air management system take up to half an hour to get working. The roof cuts out 60 per cent of the natural light so 120 specialist sports lights are used to provide the correct lighting levels. The AC system regulates the temperature and removes moisture from inside the stadium so conditions are as similar to a roofless atmosphere as possible.

The roof has revolutionised one of the world's most famous sporting events by allowing matches to go on while the traditional rain is lashing down.

HOW TRUSSES ARE DEPLOYED





© Populous

1 Control gear boxes
They operate the actuators.

2 Trusses
Each of the ten steel trusses that span the court weighs 70 tons.

3 Actuators
Electronic actuators push down on the arms between the trusses.

4 Arms
As the arms are pushed, they spread the trusses apart.

5 Lights
120 sports lights are carefully arranged so the court is evenly lit.

6 Bogies
The trusses run on these wheeled trolleys that run along a rail.

7 Locking arms
Arms across the top of the roof lock in place to withstand wind and rain.

8 Time
It takes about eight to ten minutes for the roof to close.

DID YOU KNOW...

New fighter pilot helmets offer goggleless nightvision

Fighter aircraft usually have displays built into the windscreen so the pilot can see the information coming from their instruments (speed, altitude, warnings and such) without needing to look down. This might seem like a small thing, but if you are in the midst of a dogfight, taking your eyes off your adversary even for a second could be deadly. Rather than using a projector to shine the data onto the windscreen, though, the new Striker II has incorporated the display into the helmet.

A tiny projector shines the data onto the inside of the helmet's visor – kind of like the display inside the Iron Man suit – directly in front of the pilot's eyes. Not only does this mean the instrument information is always in view but the

Striker also uses motion sensors to track where the pilot is looking.

BAE has taken advantage of this display technology to incorporate night vision. Night-vision goggles are already used in fighter aircraft, but they have to be put on when needed. On top of that, they are hefty pieces of kit, which can add to the load on the pilot's neck. Instead, the Striker II has a compact night-vision camera in the top of the helmet. This keeps the weight of the system in line with the head instead of hanging off the front. The night-vision picture is then combined with the helmet display so the pilot does not need to change over to the goggles and when they look around they have a synchronised view of the outside world, whatever the time of day.

DID YOU KNOW...

Data can be sent using light waves (Li-Fi)

Li-Fi is a super-speedy alternative to Wi-Fi

Li-Fi is like Wi-Fi except it uses visible light to send and receive data, instead of radio waves. Light and radio waves are just different frequency ranges in the same electromagnetic spectrum, but using light waves definitely has some big advantages.

First, the visible light range of the spectrum is 10,000 times bigger than the entire radio spectrum, and Wi-Fi is restricted to a tiny slice of that. So Li-Fi can fit more data into its signal. Speeds of up to one gigabit per second have been reached in real-world tests, with greater speeds achieved in the lab. Li-Fi is cheap too; it uses simple LEDs to broadcast data by flickering them on and off so rapidly that, to the human eye, they don't even appear to be lit at all. The range of Li-Fi is much shorter than Wi-Fi, as it won't travel through walls or floors, but this improves security because it is much harder for a hacker to eavesdrop on your signal. Homes and offices can be fitted with a cheap repeater in every light socket, and the signal works after bouncing off walls and furniture, so it doesn't need a direct line of sight. Li-Fi won't replace mobile phone technologies like 4G, or the microwave wireless links used to connect buildings, but its speed, low cost and security could make ordinary Wi-Fi redundant in the years to come.

IS THE TECHNOLOGY REALLY NEW?

Invisible light pulses have been used to send digital data for at least 35 years. In the 2000s many computer devices used the IrDA infrared standard, but IrDA needs line of sight to work. Infrared occupies a smaller slice of the electromagnetic spectrum than the visible light range used by Li-Fi. That means it's about 250 times slower than Li-Fi. This technology isn't a revolution; it's an evolution that combines the omnidirectional advantage of Bluetooth with the low cost and security benefits of IrDA. It does so at a speed that leaves both Bluetooth and IrDA – and even Wi-Fi – standing.

Your TV remote is the ancestor to the modern Li-Fi transceiver

WIRED FOR LIGHT

LI-FI IS CHEAP ENOUGH TO CONNECT EVERYTHING IN THE HOME OR OFFICE

INTERNET CONNECTION
Ceiling-mounted lights are wired to the office Ethernet to connect users to the internet

ONE-WAY TRAFFIC
Some devices only need to receive data, such as a clock that uses the internet to stay synchronised

ACCESS POINTS
Every light fitting can be converted to an access point, simply by replacing the current bulb with a Li-Fi-enabled one

INTERNET OF THINGS
A battery-powered sensor stuck in a pot plant could send an instant message asking to be watered

PRIVACY SCREEN
Li-Fi won't pass through walls or doors, which makes it more secure than Wi-Fi

INVISIBLE DATA
Signals are broadcast as a flickering in the background lighting, far too faint for humans to see

LI-FI DONGLE
A simple USB dongle can connect any computer to the Li-Fi network

DID YOU KNOW...

The colour of sunset is determined by the wavelength

The electromagnetic radiation given off by the Sun contains a wide spectrum of wavelengths, and human eyes are sensitive only to certain parts of it. The colours we see depend not only on what our eyes are sensitive to, but also on what has happened to the light before it has reached us and how the Sun is reflecting it, because different colours are associated with different wavelengths according to the spectrum. When the Sun sets, its position in the sky is low compared to where it sits in the middle of the day. Therefore, the light emitted has to take a different path. Its longer journey through the atmosphere means the colours with shorter wavelengths, such as blues and greens, are scattered and dispersed by the atmosphere, leaving mostly reddish components of light (those with longer wavelengths) to reach our eyes.

"The colours we see depend not only on what our eyes are sensitive to, but also on what has happened to the light"

THE SUNSET SPECTRUM

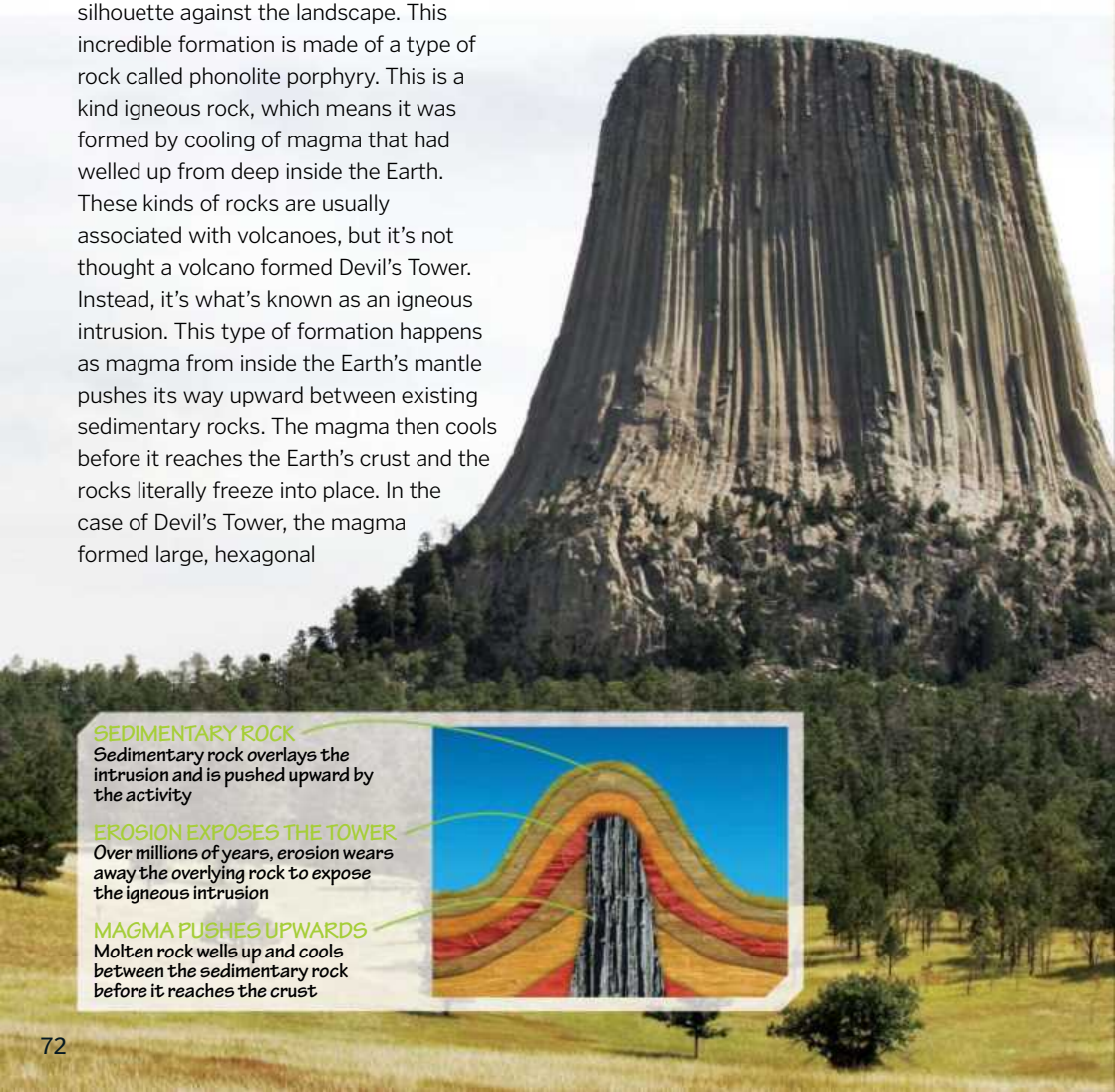
The colours that the Sun's light casts in the sky is entirely dependant on its position, and how the light is cast through the particles in the atmosphere. Long journeys produces red, but shorter journeys produce yellows and blues, depending on their place on the spectrum of light.



DID YOU KNOW...

Devil's Tower was formed by cooling magma

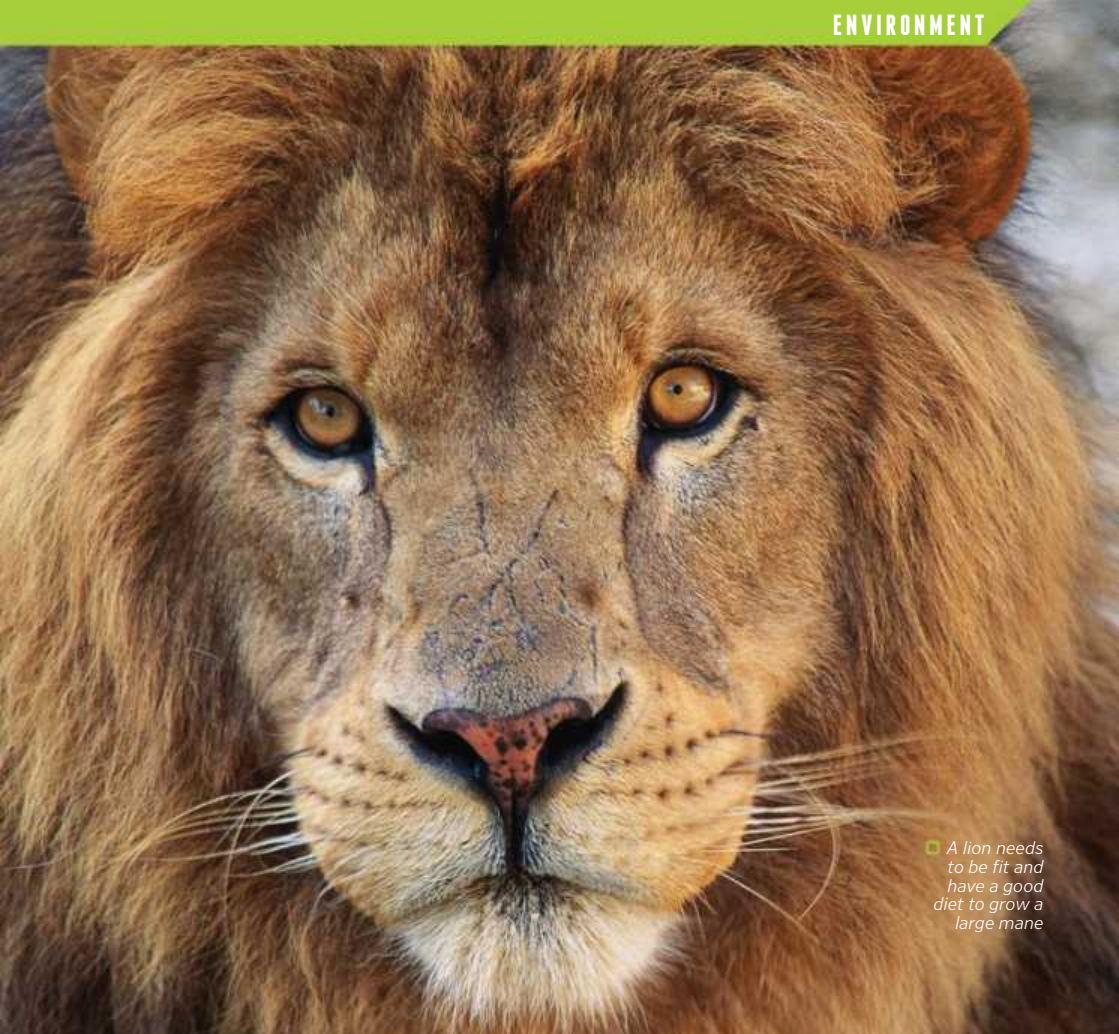
Devil's Tower is a huge rock formation that juts out of the ground in northeastern Wyoming in the United States. It is a 386-metre (1,267-foot)-high chunk of solid rock that forms a striking silhouette against the landscape. This incredible formation is made of a type of rock called phonolite porphyry. This is a kind igneous rock, which means it was formed by cooling of magma that had welled up from deep inside the Earth. These kinds of rocks are usually associated with volcanoes, but it's not thought a volcano formed Devil's Tower. Instead, it's what's known as an igneous intrusion. This type of formation happens as magma from inside the Earth's mantle pushes its way upward between existing sedimentary rocks. The magma then cools before it reaches the Earth's crust and the rocks literally freeze into place. In the case of Devil's Tower, the magma formed large, hexagonal columns as it cooled. It's thought this formation happened within the Earth, and the continuous erosion of wind and rain has slowly exposed the Devil's Tower we know today.



SEDIMENTARY ROCK
Sedimentary rock overlays the intrusion and is pushed upward by the activity

EROSION EXPOSES THE TOWER
Over millions of years, erosion wears away the overlying rock to expose the igneous intrusion

MAGMA PUSHES UPWARDS
Molten rock wells up and cools between the sedimentary rock before it reaches the crust



A lion needs to be fit and have a good diet to grow a large mane

A male lion's mane determines its strength

It is believed that the mane evolved to protect a lion's neck in a fight; however, Peyton West from the University of Minnesota led a trial involving dummy lions and discovered that, actually, it's not often the neck that is targeted. The real lions attacked the dummies but mainly went for the backside. While it is thought that during evolution the mane served as protection, now the mane acts as a sign of strength.

The mane can overheat a lion and makes them stand out to predators, so only the strongest survive with a large mane. Females are attracted to this, and other lions pick fewer fights.

DID YOU KNOW...

A usual cuppa comes from the Camellia plant

Tea, the hot beverage enjoyed so much in the UK that it has become as quintessentially British as the Queen, begins its life as juicy young leaves on a bush of the Camellia family. The species Camellia sinensis originates from China and the Camellia sinensis assamica variant is the Indian tea variety. Tea bushes are grown in vast crops in hot, humid areas with regular rainfall. China, India, Sri Lanka and Kenya are the top four countries, representing 75 per cent of the world's tea production. Factors such as climate, altitude and humidity affect the quality and taste of the tea crop – much in the same way as grapes and wine – and their leaves are expertly selected and plucked by hand.

Black tea, the kind you're probably enjoying with milk and one sugar as you read this, is made from new, tender tea shoots, typically the first few leaves and a bud. Once picked, the leaves go through four main steps before they're ready for brewing and accompanying some cake: withering, rolling, oxidation and drying. For different tea varieties, these steps are modified and adapted, which helps to produce such a huge array of different tea flavours and types.

© Thinkstock

FROM PLANT TO CUP

PLUCKING

Leaves are never plucked from the plant individually; they are always removed as a group of one, two or three leaves along with the bud that forms at the end of the stem

THE PLANT

Tea leaves grow on bushes in vast crops. If left untended the tea plant could reach up to 20m (65ft) tall, but the bushes are usually pruned at the 'plucking table' around 1.2m (4ft) – this helps hand-picking and promotes bud growth

DRYING

Tea leaves are then dried in order to stop the oxidation process at precisely the right time to make sure the tea's flavour is just right. The oxidised leaves are gently heated to remove all excess moisture

PACKAGING

After the tea is dried, it is sorted into grades depending on the dried leaf's size. Larger leaves are sold for loose-leaf tea and smaller ones are prepped for use in tea bags

DIFFERENT TYPES OF TEA

The four main types of tea are black tea, green tea, white tea and oolong tea. They all originate from the same plant, and it is their preparation that defines their taste. White teas only use the very first buds at the top of a new season's tea plant, which can only be plucked once a year. All four types of tea leaves are withered first – a process that reduces the moisture content.

Once withered, leaves for making green tea are then steamed or pan-fried. This stops the oxidation process – meaning there is no further reaction with oxygen – which is why the leaves keep their natural green colour, giving the tea its name.

Oolong tea is semi-oxidised, placing it somewhere between green and black tea. The partial oxidation allows the leaves to briefly ferment, producing a more distinctive flavour. The leaves are then rolled and dried ready for brewing.

WITHERING

The freshly picked leaves are laid out in large troughs or shelves to wither for eight to 12 hours. Air is often passed through in order to help the removal of moisture, and after withering the leaves look wilted

ROLLING

The leaves are broken up and the enzymes are released in preparation for oxidation. There are two rolling methods: Orthodox, where rollers gently break leaves; and CTC – cut, tear, curl – where leaves are cut by a machine

OXIDISING

The withered and rolled tea leaves are laid out for a few hours to oxidise, which means they react with oxygen and begin to ferment. The leaves undergo chemical processes where they partially break down

THE CUP

The tea is then ready for brewing. The dried tea leaves infuse hot water with the delicate taste that's governed by the growing conditions and careful preparation process. Pop the kettle on!

"Every day, an epic migration can be witnessed within the lake, as the jellyfish move to the eastern side of the lake in the morning and then back west again in the evening"

Scuba divers can't go beyond 15m deep in Jellyfish Lake

Found off the coast of Koror, Palau in the Philippine Sea, a rocky island uninhabited by humans is host to a colossal colony of jellyfish. The Ongeim'l Tketau marine lake, more commonly known as Jellyfish Lake, is just one of about five Palauan lakes inhabited by these glutinous beauties. The lake itself is an average of 30 metres (98 feet) deep and is connected to the sea by cracks and fissures in the rock.

The unusual chemical parameters of the lake mean it is highly stratified. The uppermost 'layer' of water is rich in oxygen, but around 15 metres (49 feet) beneath the surface the anoxic bottom layer begins – an oxygen-depleted zone high in hydrogen sulphide that makes the depths of the lake a no-go area for scuba divers.

However, swimming in the top layer is permitted – and recommended – as the whole water body is teeming with both golden jellyfish and moon jellyfish species. Neither species' stings are dangerous to humans.

These fascinating animals are able to grow to such large numbers as the lake provides a safe, enclosed ecosystem with very few natural predators. However, there is one sea anemone species living in the lake that has a definite taste for a jellyfish supper.

Every day, an epic migration can be witnessed within the lake, as the jellyfish move to the eastern side of the lake in the morning and then back west again in the evening, tracking the progress of the Sun. It's thought that this daily migratory behaviour helps the jellyfish avoid the shady shoreline areas where the jelly-hungry anemones can be found lurking in wait for an easy meal.

The lake is filled with golden and moon jellyfish

DID YOU KNOW...

An egg yolk is released from a hen's ovary every 26 hours

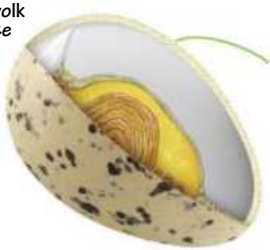
Whether you boil, fry or scramble them, eggs are one of the most versatile ingredients in the kitchen. But have you ever wondered about the ones that don't make it onto the plate? These little capsules happen to be some of the most wondrous things in the natural world. A brittle shell protects a gloopy inner of the familiar 'yolk' and 'white'. The yolk is released as the chicken ovulates; it can then be fertilised, and continues to travel through the hen's reproductive tract. The white of the egg is comprised of various different layers of albumin, structural fibres and membrane, which surround the yolk as it travels through. Finally, the eggs are 'shelled' and laid by the hen usually 24 hours later. The fertilised yolk contains all of the genetic information needed to create a newborn chick.

THE EGG

GET TO GRIPS WITH EGG DEVELOPMENT

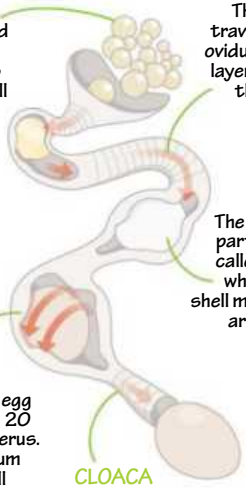
2. THREE DAYS' INCUBATION

Blood vessels are present, and the embryo has a heartbeat. After five days, there is substantial growth and the tiny chick has an eye. The embryo feeds on nutrients from the yolk through the blood vessels



1. FERTILISED EGG

The embryo begins to develop at one side of the yolk – this is held in place in the centre of the egg white by a protein cord called the chalaza



OVULES

One ovule (egg yolk) is released from the hen's ovary every 26 hours, but it will only be fertilised if the hen has mated with a rooster

DESCENT

The ovule then travels down the oviduct and gains layers of albumin that form the egg white

ISTHMUS

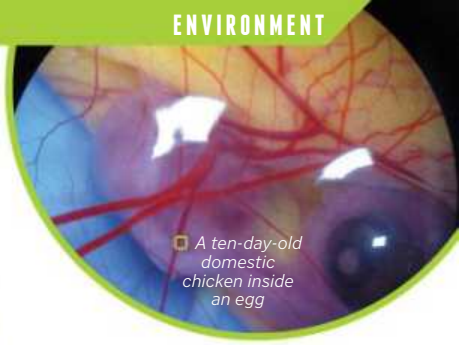
The ovule reaches a part of the oviduct called the isthmus, which is where the shell membranes form around the yolk and white

UTERUS

The developing egg spends around 20 hours in the uterus. Here, the calcium carbonate shell hardens and any colour pigments are deposited

CLOACA

The egg is laid. The whole process takes around 26 hours



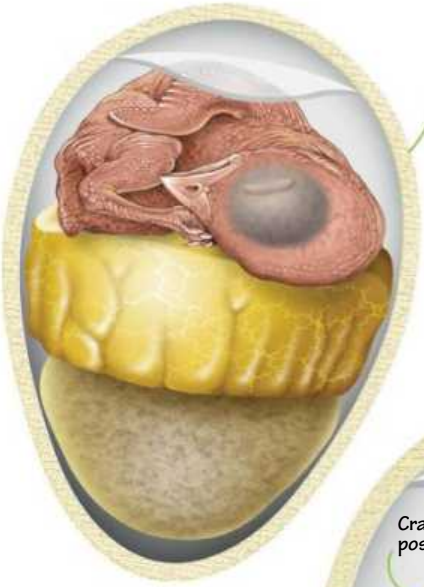
A ten-day-old domestic chicken inside an egg

3. NINE TO ELEVEN DAYS' INCUBATION

The embryo's neck has lengthened and its brain is developing. Claws, legs and wings begin to show and lengthen, and there are also feather follicles forming as more blood vessels draw sustenance from the yolk

4. 14 TO 17 DAYS' INCUBATION

The embryo now fully resembles a chick, down has covered its body, and days 15 and 16 are spent growing. By day 17, the egg white is used up, and the chick starts to get into hatching position



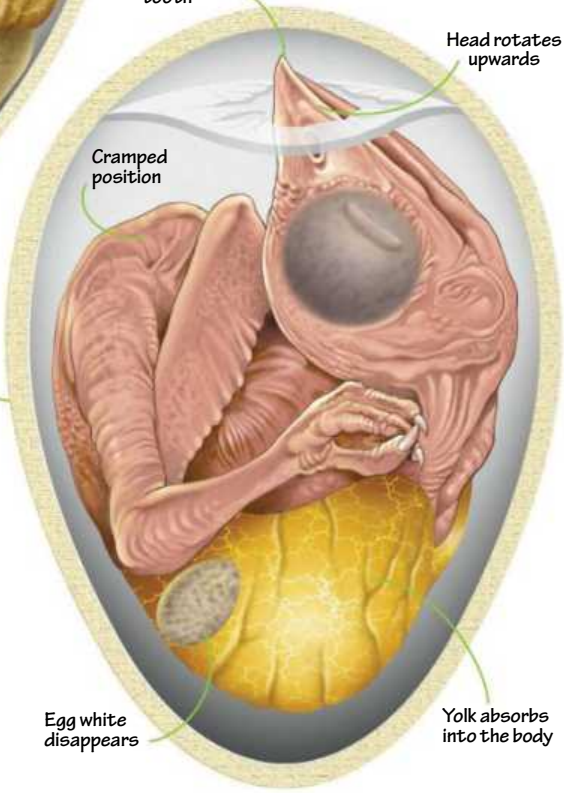
SHAPE

Eggs are advantageously oval-shaped. They are easier for birds to lay, fit snugly into a nest, and they roll in a circle

Oval is the most common egg shape

Seabirds nesting on cliffs often lay conical eggs – they roll in a tight circle to better avoid edges

Spherical eggs (which are laid by owls and woodpeckers) are better at conserving heat



5. HATCHING

After 20 days, the white and yolk have been absorbed and the chick is fully formed. It has rotated within the egg so that it can break the shell using its egg tooth – the hardened end of its tiny beak

COLOUR AND TEXTURE

Disguising eggs from hunters is key to survival for birds. Texture and colour can tailor an egg to a bird's surroundings

Dark egg

Light egg

Speckled egg

DID YOU KNOW...

Cats react to an active ingredient in catnip called nepetalactone

It's the oil in catnip that makes felines go crazy

There is an oil found in the catnip plant called nepetalactone. Researchers believe that when this oil enters a cat's nasal tissue, it binds to protein receptors that stimulate sensory neurons. This leads to a response in neurons in a part of the brain known as the olfactory bulb which projects to other brain regions; regions that not only mediate emotional responses to stimuli (causing a behavioural response), but also regulate neuroendocrine responses, making the cat react to an artificial cat pheromone. It doesn't affect all cats, but many react by rolling around, flipping over, becoming hyperactive and sometimes acting aggressively, before experiencing a come down ten minutes later.

An average cloud weighs 500 tons

If you consider the weight of the water droplets the average cloud contains, it weighs in at around 500 tons. Clouds are made up of tiny droplets of water or ice crystals, suspended in the air. On average, a cumulus-type cloud – the white, fluffy type – has a volume of one cubic kilometre (0.24 cubic miles), containing 0.5 grams (0.018 ounces) of water per cubic metre (35 cubic feet). This adds up to a total of 500 tons, although in reality this can vary significantly based on the size of the cloud. Despite this huge weight, clouds still float because the dryer air below them is denser.

White waves are caused by lots of water droplets

The white foamy surf we see in breaking waves as they come in to shore is actually made up of lots of tiny droplets containing bubbles of air. These air bubbles do not absorb as much light as pure water droplets, so the light that has passed through them is brighter than the surrounding sea.

This is what usually gives surf its white appearance. This effect is more noticeable when seas are rough because the churning waves produce more aeration and therefore more bubbles. Pollution or dissolved organic matter in the sea (often produced by the decay of algal blooms) can also create white foam along the shore.

Only the breaking part of the wave appears white; the rest of the water remains transparent

DID YOU KNOW...

The largest lizard on Earth can take down a water buffalo

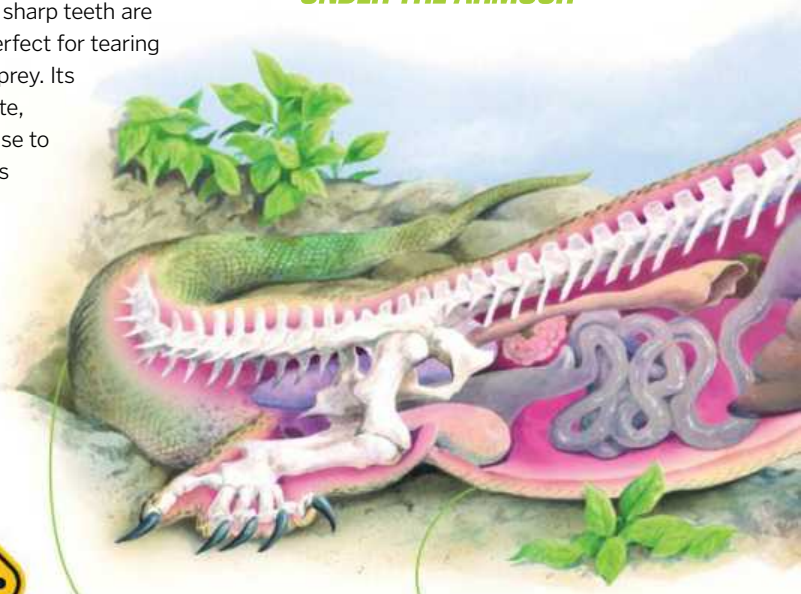
This real-life dragon is far more fascinating than any mythical beast of fiction. These powerful lizards are opportunistic carnivores and eat almost anything they can find, including the young of their own species. There aren't many kinds of meat that a Komodo dragon will turn its snout up at – with their keen sense of smell they can detect and track down carrion from several kilometres away.

The Komodo dragon's sharp teeth are curved and serrated – perfect for tearing chunks of flesh from its prey. Its killer move is the belly bite, which the Komodo will use to bring down larger victims like water buffalo. The bite itself is rarely fatal, allowing the target to evade capture, but victory is short-lived.

The dragon knows the damage is done as its bite did more than draw blood. A potent mixture of chemicals from its venom glands seeps into the wound, preventing the blood from clotting, so their victims eventually bleed to death.

With a flicker of its forked tongue, the Komodo tracks the buffalo's location by scent and will devour almost every part of its prey – hide, hooves and bones included.

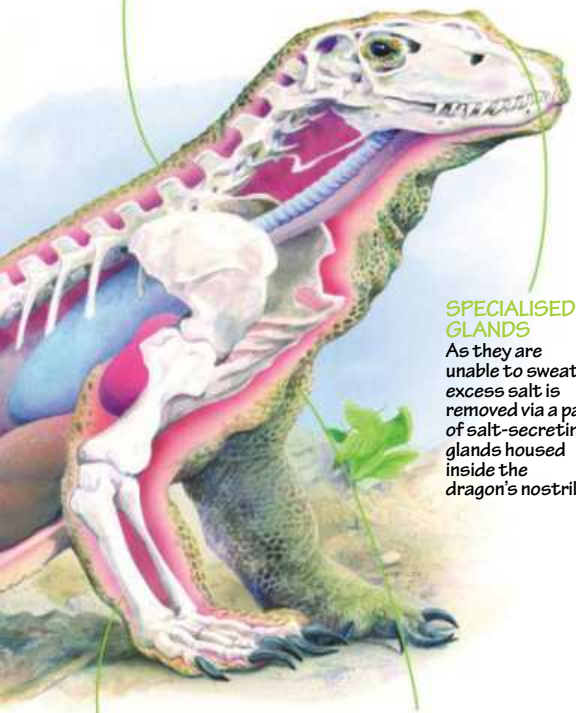
UNDER THE ARMOUR



LETHAL TAIL
Measuring the same length as its main body, the tail is composed of thick muscle. The Komodo is capable of knocking over an adult deer with one swipe

LOW PROFILE
The Komodo is huge, typically measuring over two metres (6.6ft) in length, but they stand at a height of only 40cm (15.7in), which enables them to sneak up on prey

BONY ARMOUR PLATES
A Komodo's skin is incredibly tough as it is covered in osteoderms – bony plates that form their strong and scaly armour



SPECIALISED GLANDS
As they are unable to sweat, excess salt is removed via a pair of salt-secreting glands housed inside the dragon's nostrils

ADAPTABLE SKIN
When the Komodo feeds, its skin stretches out, enabling it to consume a whopping 80 per cent of its body weight

STURDY LEGS
The legs of a Komodo bow outwards, forcing them to weave as they walk. Each foot has five lethally sharp claws

HOW A DRAGON KILLS

THEORY 1: DEADLY PATHOGENS

For many years it was believed that Komodos killed by infecting their prey with bacteria found in their mouths, but it turns out that this isn't the case. Levels of oral bacteria were too low to infect something as large as a water buffalo, which completely rules out this theory.

THEORY 2: VENOM

Back in 2009, scans of a Komodo's head found two previously undiscovered venom glands in the dragon's lower jaw. These scans also demonstrated the self-inflicted damage that their 'grip and rip' attacks can cause on their jawbones.

THEORY 3: DEVASTATING ATTACK

The combination of venom delivery and vicious attack is now the prevailing theory as to how Komodos kill. They can deliver toxic proteins via gaps between their teeth, so that when they bite with their serrated teeth, venom oozes into the wound.

DID YOU KNOW...

Frost flowers grow on frozen lakes

They may look like strange plants or even sea creatures, but these beautiful formations are actually intricate ice sculptures that grow naturally on thin ice. They have been spotted on frozen lakes, ponds and sea ice, but require very specific conditions to form. The air above the surface of the ice must be still, dry and about 20 degrees Celsius (68 degrees Fahrenheit) colder than the temperature of the ice itself. This makes it possible for the surface ice to sublimate, meaning that it changes directly from a solid to a gas, skipping the liquid stage in-between. As this water vapour hits the cold air above the ice, it condenses to form ice crystals that attach to imperfections or cracks on the surface. With little wind, the crystals do not blow away, and are left to grow naturally into stunning frost flowers. As they grow, the flowers also draw up more water from the ice below, and this often contains microorganisms. The density of bacteria found in frost flowers means that each one is its own ecosystem.

Frost flowers are typically found in the Arctic and Antarctic

Dogs act cute so we love them

Seeing an adorable dog tilt his head is one of the cutest things to witness – it's as if your furry friend is confused. There are a few theories as to what makes dogs do this.

One explanation is that the dog rearranges his stance in order to better hear or see us. When a dog looks at you, their muzzle is blocking half of the view; cocking their head allows them to get a better look, especially at our faces, enabling them to adeptly judge emotional and physical clues from the way we act.

Another reason is that Fido knows we squeal with delight and shower him with love when he does it. Dogs learn this quickly and will use it to their advantage.

Dogs may tilt their heads into a better position to aid their hearing

Due to the precise angle of refraction, sundogs always appear roughly 22 degrees to the left and right of the Sun

Ice crystals cause sundogs

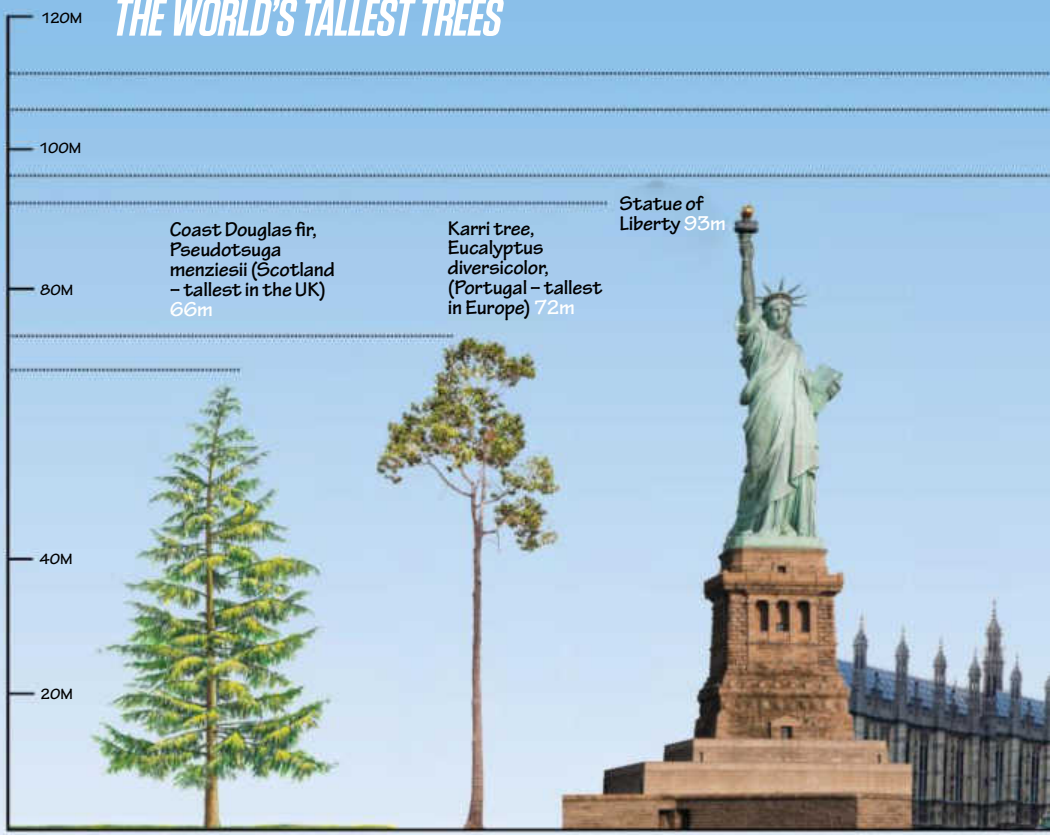
If you've ever seen what appear to be three bright Suns lined up neatly on the horizon, then you've probably witnessed sundogs. This rare phenomenon occurs when hexagonal ice crystals in the air align to refract sunlight into your eye at a precise angle. This forms a halo of light around the Sun, with two bright patches on either side of it called parhelia, or sundogs.

Even rarer are jumping sundogs, which occur when lightning discharge in a thundercloud temporarily changes the electric field above it. This adjusts the orientation of the ice crystals so that they refract the sunlight differently, making the sundogs move around as if they're jumping.

DID YOU KNOW...

Trees help us fight climate change

Trees are the lungs of our planet. As a key part of the carbon cycle, when trees photosynthesise to make their own food, they take in carbon dioxide and convert it to release oxygen, storing the rest of the carbon that gets decomposed into the soil when the tree dies. When a whole forest does this, the intake of CO_2 is huge. With rising CO_2 levels in our atmosphere being an important factor in climate change, the work of trees becomes all the more prominent. It's estimated that our planet's trees absorb up to 40 per cent



Height (m)

Trees versus buildings

Giant redwoods thrive in the warm, humid climate of northern California

of the carbon dioxide created by humans each year.

When the trees are cut down, this carbon storage is removed, but so is the tree's ability to stabilise the earth and take up water. Deforestation creates a landscape where water flows uninterrupted, taking valuable, nutrient-laden surface soil with it. This leaves land barren and infertile – a disaster for agriculture and those who depend on farming for their livelihood. Flash floods wreak havoc and threaten human life, and have been directly linked to the removal of trees across the world. Downstream, the soil that has been removed by floods is deposited as the flow peters out, and can clog up dams and create further issues.

"Deforestation creates a landscape where water flows uninterrupted, taking valuable nutrient-laden surface soil with it. This leaves land barren and infertile - a disaster for agriculture and those who depend on farming"

DID YOU KNOW...

The world's largest crystals are in Mexico

Two brothers were drilling in the Naica mine in Mexico when they uncovered a geological, hundreds of thousands of years in the making. The Cueva de los Cristales, or Cave of Crystals, is a glittering palace covered in some of the largest crystals anyone has ever seen. Measuring over 11 metres – they have thrived in the extreme conditions of the cave.

Temperature is a sweltering 44 degrees Celsius and up to 100 per cent humidity means the air you breathe quickly condenses inside your lungs. Geologists exploring the cave had to don specially designed suits, strewn with ice packs. If they had taken their respirator mask off for more than ten minutes, they would have fallen unconscious. However, what proves deadly for humans are the perfect conditions for growing crystals.

These monstrous structures are made of a soft mineral called selenite, and formed from groundwater saturated with calcium sulphate, which was heated by a magma chamber below. As the magma cooled, the minerals in the water started to transform into selenite and steadily built up. The cave's oldest resident is 600,000 years old – forming at the time when the ancestors of modern humans first appeared.

The crystals stopped growing when miners unintentionally drained the cave in 1985 while they lowered the water table. When the mine stops being profitable, the owners of the Naica mine will remove the pumps and the cave will flood once more.

"The cave's oldest resident is 600,000 years old"

DID YOU KNOW...

Other planets have Auroras too

For many years, the auroras seen on our planet were thought to be the souls of the dead moving to the afterlife. An Aurora on Earth is actually caused by the Sun and can be thought of as a form of space weather. Solar winds hit Earth with highly charged particles, but our planet's magnetic field deflects most of them before they reach the atmosphere. Every so often these winds are boosted by solar flares or coronal mass ejections, which release huge amounts of plasma. When these intense solar winds reach Earth, some of the ionised particles get trapped in the magnetic field.

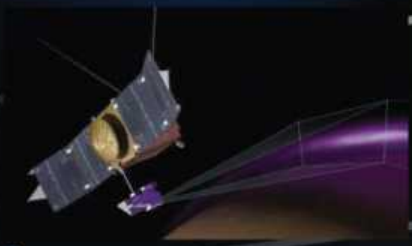
VENUS

Similar to Mars, Venus does not possess its own planetary magnetic field, but flashes of light from the planet have been identified as auroras. Scientists have found that the same process that causes auroras on Earth can form a gigantic magnetic bubble around Venus, allowing auroras to occur. This is possible due to Venus having a magnetotail, which was formed by ionosphere and solar wind interaction. The fact that magnetic reconnection can occur within Venus' magnetotail suggests auroras are the cause of the light that scientists have observed emitting from this planet.

You can clearly see the difference in the magnetospheres of Venus (top) and Mars (bottom) compared to Earth

MARS

On Mars, auroras appear near areas of magnetised rock within the planet's crust rather than near the poles, when charged solar particles concentrate toward them. This is because it lacks a self-generated magnetic field, possessing only 'crustal magnetic anomalies'. Scientists found that the location of the light emissions corresponded with the location of the strongest magnetic fields found on Mars. It is thought these anomalies are the last traces of Mars's planetary magnetic field, which it displayed at some time in its history. This type of aurora formation is totally unique to Mars as far as scientists are aware.



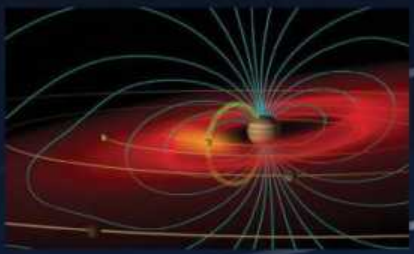
NASA's Mars Atmosphere and Volatile Evolution (MAVEN) spacecraft observing the 'Christmas Lights Aurora' on Mars

These particles are then accelerated along the field lines toward the poles where they can enter the upper atmosphere, colliding with gas particles that cause them to emit bright light. This process creates the mesmerising aurora borealis and aurora australis, more commonly known as the northern lights and the southern lights respectively.

On Jupiter, Saturn, Uranus and Neptune, auroras form in a similar manner to how they form on Earth. But on Mars and Venus they form very differently, as neither of these planets possess a significant magnetic field.

JUPITER

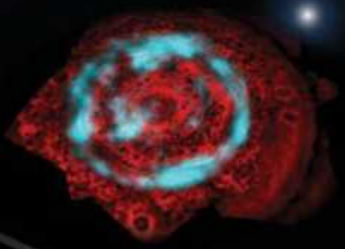
Although some of the auroras found on Jupiter form in a similar manner to those on Earth, many are formed due to the trapping of particles within its own magnetic environment. Unlike Saturn's main aurora that changes size as the solar winds vary, Jupiter's main auroral ring maintains a constant size. This is due to its formation through interactions within its own magnetic environment. Jupiter's moons are also believed to be able to influence auroras. Io, Jupiter's volcanic moon, is thought to produce gases that travel into Jupiter's atmosphere, where they can contribute to the planet's aurora formation.



This shows Jupiter's magnetosphere and how its moons become involved in aurora formation

SATURN

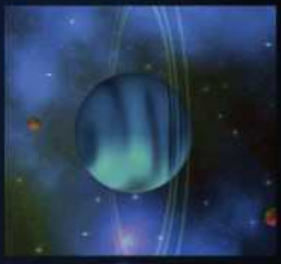
Saturn's auroras differ from Earth's in their size; they can stretch to amazing heights of 1,000 kilometres (621 miles) above Saturn's cloud tops. The charged particles come from the Sun's solar winds blasting past the planet. The particles smash into hydrogen in Saturn's polar atmosphere, ionising the gaseous atoms, which causes photons to be released and leads to the aurora. This planet's auroras are actually not visible to the human eye, due to the fact that the emitted light lies in an infrared and ultraviolet spectrum we can't see. It's thought that as on Jupiter, Saturn's moons may also influence the auroras.



Saturn's auroras occur near the planet's poles, much like they do on Earth

URANUS

The presence of auroras on Uranus was detected in 2011 by Hubble. It is thought this was possible due to heightened solar activity during this period, which increased the amount of charged particles carried in solar winds from the Sun. The auroras formed on this giant ice planet appear far away from the north and south poles, unlike on Earth. This is because of the planet's magnetic field, which is inclined at an angle of 59 degrees to the axis of its spin. These auroras are fainter than their Earth counterparts and last only a couple of minutes, unlike those on our planet, which may last for hours at a time.



Uranus has a mass over 14 and a half times that of Earth's

DID YOU KNOW...

Earth formed over 4.6 billion years ago

A TIMELINE OF EARTH

THE KEY EVENTS IN OUR PLANET'S PAST, PRESENT AND FUTURE

- PAST
- FUTURE

4.6 BILLION YEARS AGO
Earth forms as our Solar System begins to take shape from clouds of dust and gas surrounding the young Sun.

4.5 BILLION YEARS AGO
The Moon is formed.

4 TO 3.8 BILLION YEARS AGO
Asteroids and comets rain down in abundance, in the Late Heavy Bombardment period.

3.5 BILLION YEARS AGO
The oldest known life arises – single-celled microorganisms. It's unclear if life began on the seabed, in open water or land.

535 MILLION YEARS AGO
The Cambrian explosion starts, a seemingly short evolutionary event of just 25 million years when most of the major animal groups emerge for the first time. The reason for this 'explosion' is unknown, but it may be partly down to better fossilisation now that animals have hard shells.

500 MILLION YEARS AGO
Some animals make the move onto land. The first to do so are thought to be 'euthycarcinoids', the evolutionary link between insects and crustaceans.

250 MILLION YEARS AGO
In the aftermath of a mass extinction, the dinosaurs emerge, and rule over Earth for almost 200 million years.

HOW LONG HAVE HUMANS BEEN HERE?

In the grand scheme of things, a very, very short amount of time. If you could compress Earth's history into a single year, humans would have only existed for less than half an hour! In that relatively short time, we've managed to dominate most of the planet and started exploring other worlds too.

But unless we become a multi-planet species in the near future, it's likely we're eventually going to go the way of the dinosaurs. A mass extinction event will hit us sooner or later, and many experts think we need to colonise the Moon, Mars and maybe beyond to ensure the survival of our race.

4 BILLION YEARS
The Andromeda galaxy collides with the Milky Way, although it's unclear how this will affect our Solar System – aside from looking rather pretty in the night sky.

500 MILLION YEARS
Our Sun's temperature increases to a point where most of Earth's surface is a desert. Over the next few billion years, the largest remaining organisms on Earth will die out, leaving only insects and bacteria.

5 BILLION YEARS
The Sun uses up the last of its hydrogen fuel. It may consume Earth or the planet may spiral out of its reach.

1 TRILLION YEARS
This is the upper limit for when the Sun will stop radiating energy, becoming a cold black dwarf.

3 BILLION YEARS AGO
Plate tectonics begins on Earth, with the surface being split into giant plates of rock. We call Earth's first continent 'Ur'.

2.3 BILLION YEARS AGO
A lack of volcanic activity causes our planet to freeze over, becoming a 'Snowball Earth'.

2 BILLION YEARS AGO
Eukaryotic cells, which have a nucleus, mitochondria and membranes, begin to emerge on our planet.

3.4 BILLION YEARS AGO
Photosynthesis begins, as early microorganisms use energy from sunlight to turn molecules into sugars.

2.4 BILLION YEARS AGO
Oxygen enters the atmosphere as bacteria begin to produce the gas now essential to life. This is known as the Great Oxidation Event.

1.5 BILLION YEARS AGO
The eukaryotes split into three groups that ultimately give rise to plants, fungi and animals.

650 MILLION YEARS AGO
The first complex life on the planet, most likely jellyfish, come into existence.

900 MILLION YEARS AGO
Multicellular life develops for the first time, although no one knows the exact process behind how this happened. Finding the answer could maybe help us find life on other worlds.

7 MILLION YEARS AGO
The first hominid, our earliest ancestor, comes onto the scene. It's called Sahelanthropus tchadensis.

65 MILLION YEARS AGO
The dinosaurs (along with pterosaurs and giant marine reptiles) are wiped out when an asteroid hits Earth, called the Cretaceous-Tertiary extinction event. This allows mammals to ultimately rule over the planet.

60 MILLION YEARS AGO
The oldest known primates evolve in the hot and humid rainforests of Asia.

PRESENT DAY

100,000 YEARS FROM NOW
Statistically, a large asteroid or a supervolcano is likely to have wiped out most of life on Earth by now, including us.

2,000 YEARS FROM NOW
The Greenland ice sheets melt, drastically raising sea levels across the world.

200,000 YEARS AGO
Finally, after quite a wait, the first humans (Homo sapiens) arrive. Within 200,000 years, they colonise almost every corner of the globe.

100 QUINTILLION YEARS
Earth's orbit decays and it falls into the Sun – whatever is left of both of them.

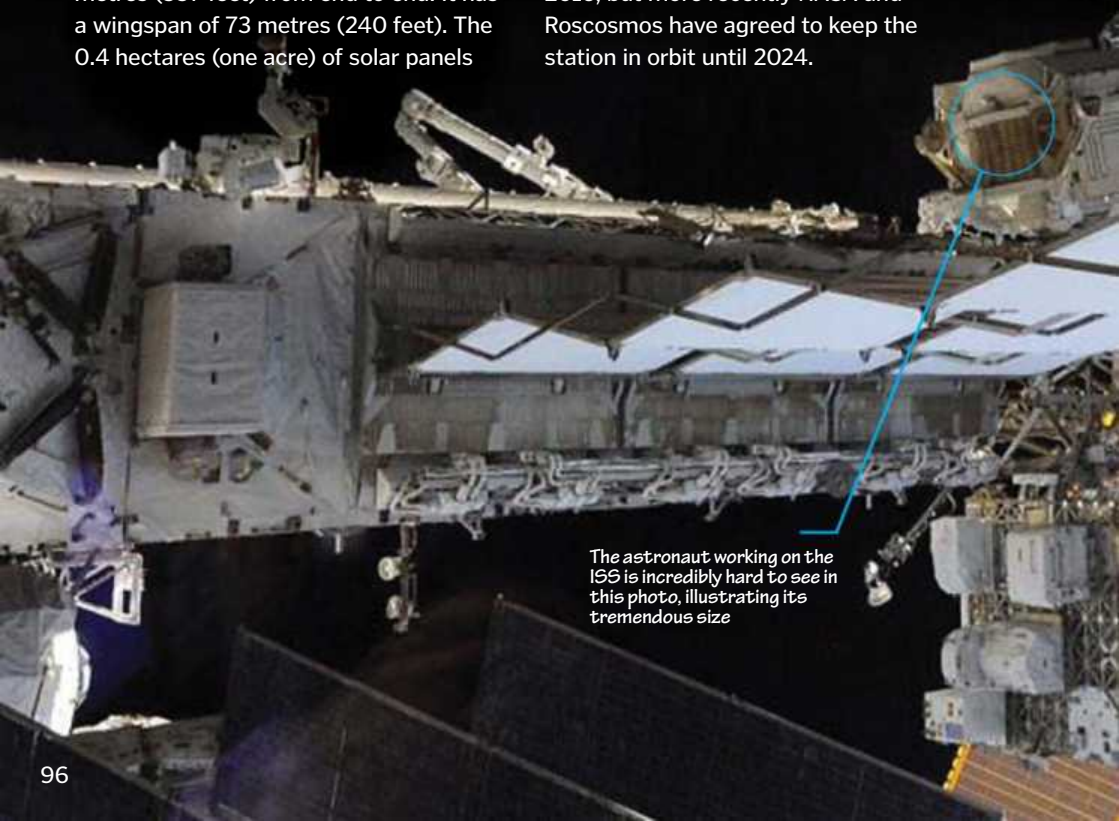
?
The last stars in the universe go out.

DID YOU KNOW...

ISS has a mass of 420,000 kilograms

The size of the International Space Station is incomparable to anything else ever launched into space. With a total mass of approximately 420,000 kilograms (925,000 pounds), it resides 400 kilometres (250 miles) above Earth in one of the lowest possible orbits, meaning that it's visible with the naked eye from the ground. It measures 108.8 metres (357 feet) from end to end. It has a wingspan of 73 metres (240 feet). The 0.4 hectares (one acre) of solar panels produce enough electricity to power the equivalent of 40 homes back on Earth. Living space on the ISS is comparable to a six-bedroom house, and is equipped with a gym, two bathrooms and a 360-degree bay window.

At the time of its tenth anniversary back in 2010, the ISS had travelled over 2.4 billion kilometres (1.5 billion miles). The ISS is still our best space laboratory; the research potential related to both life on Earth and in space is still vast, but the future of the ISS has been in danger. A decision had to be made as to whether it was worth keeping a piece of 1990s solar-powered technology that costs billions of dollars every year to operate and maintain. The US had previously considered decommissioning the ISS by 2016, but more recently NASA and Roscosmos have agreed to keep the station in orbit until 2024.



The astronaut working on the ISS is incredibly hard to see in this photo, illustrating its tremendous size

COMPARE THE ISS TO OTHER MAN-MADE CREATIONS

DID YOU KNOW...

The Sun's gravity holds the planets in orbit

The planets were set in motion during the formation of our Solar System and are held in orbit by the Sun's gravity. About 4.6 billion years ago, our Solar System was a huge cloud of dust and gas, rotating as it collapsed. As it spun it flattened out, forming the Sun at its centre and a disc of matter surrounding it. Particles of dust in this disc collided and accumulated to form planets. Without the Sun, these planets would travel off into space in a straight line, but the star's immense gravity curves their paths into orbits.

Astronauts on the ISS are constantly free-falling

International Space Station (ISS) astronauts are not truly weightless as they are still affected by the Earth's gravitational pull. However, the lack of other forces pushing on the astronauts leads to the perceived sensation of weightlessness, rather than true weightlessness.

Down here on planet Earth we experience gravity on a daily basis, as well as opposing contact forces. These forces are exerted through the ground we stand on, and give us a sense of our own weight and mass.

The ISS is in orbit around the Earth, meaning that the space station is actually constantly 'falling' towards the Earth. It is in this state of perpetual free-fall that the astronauts don't experience any contact forces, and therefore they end up feeling weightless.

An artist's impression of a starshade, blocking the glaring light of a star so its orbiting planets can be seen

Starshades are shaped like petals

Astronomers have a problem when it comes to trying to take images of planets around other stars. It is the same as our Sun. To be able to see planets that are very close to their stars, astronomers need a way of blocking the glare of a star's light so that we can see the planets in close attendance.

The tool for this job is called a starshade. It is new technology, but could be flown on a planet-finding space mission in the not-too-distant future. The idea is to have a kind of shade, measuring 34 metres (112 feet) across and floating in space in formation tens of thousands of kilometres ahead of a space telescope. The petal shape means the edge of the shade is not sharp, which means the rays of starlight do not bend as much, so the shadow cast by the shade is darker.

Scientists are conducting tests in the desert, using bright LED lights and prototype shades. If successful, starshades could soon be employed on missions such as the James Webb Space Telescope, which is due to launch in 2018.

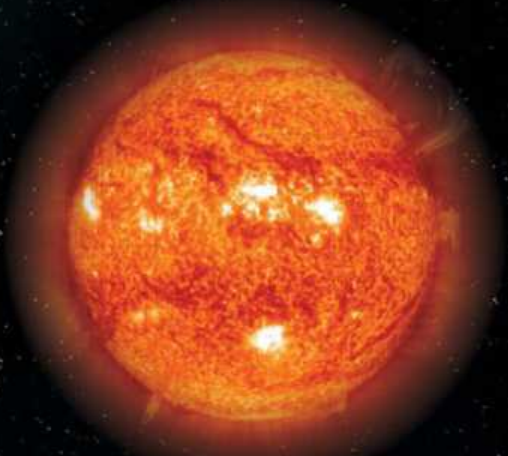
DID YOU KNOW...

We can only see a small part of the spectrum

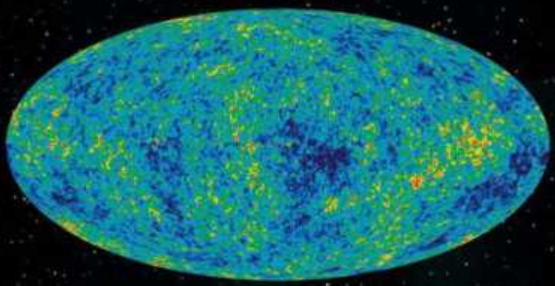
The different types of wave that can be found racing through space can be arranged together in the electromagnetic spectrum. Because of their characteristics, we're able to arrange these waves into an order. The low notes of the electromagnetic spectrum, which contains waves with not a great deal of energy, start at radio and turn progressively to higher notes – through to gamma rays, which are extremely energetic.

Being called 'waves' it's easy to imagine the components of the spectrum as similar to sound waves. With EM radiation, things are different – they don't need air to travel. They are the movement of magnetic and electric fields, so they don't need anything to help them move along. With the advent of a fleet of telescopes in space – such as the Chandra X-ray Observatory – and on the ground, we're able to see the universe in its many wavelengths.

ULTRAVIOLET
If you've ever had sunburn, then you have come into contact with radiation from space known as ultraviolet radiation. It's coming from our Sun, like many of the light waves on this list. Luckily we aren't often exposed to dangerous levels of ultraviolet radiation, since the ozone in the Earth's atmosphere catches the majority of it.



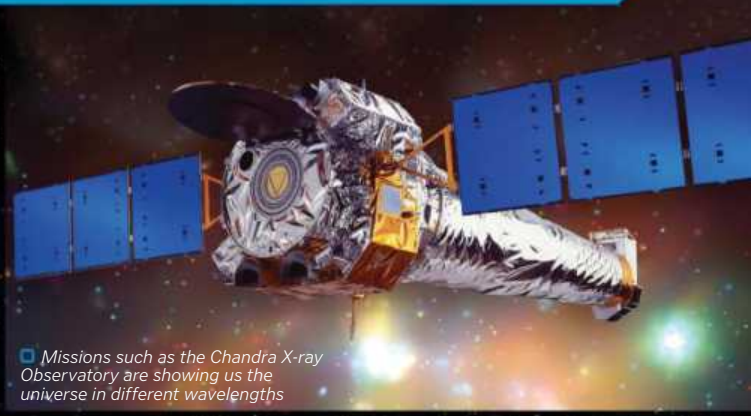
INFRARED
Anything that gives off heat is throwing out infrared radiation – you even emit a small amount from your body. It's also in space, but is invisible to the human eye. We use telescopes, such as Spitzer, which are sensitive to the infrared part of the spectrum, to find out where it's being emitted. These waves are usually detected coming from nebulae, stellar nurseries where stars are born.



MICROWAVES
You are probably most familiar with microwaves, from using them to heat up your food in cooking appliances. Microwaves can be found throughout the universe – most notably in the Cosmic Microwave Background Radiation, left over from just after the Big Bang, which permeates the universe today and is a chilly -270°C (-454°F).

X-RAYS

X-rays are made when matter is heated to millions of degrees where magnetic fields, great forces and immense gravity have a strong influence. It is this radiation that helps us to learn more about black holes, neutron stars, dark energy and dark matter.



Missions such as the Chandra X-ray Observatory are showing us the universe in different wavelengths

VISIBLE

Visible light is the light we humans can see. It's because of this part of the electromagnetic spectrum that the human eye is able to detect the observable universe – that's the stars, planets and galaxies; we're able to see without the need for infrared, gamma ray or X-ray telescopes.

GAMMA RAYS

Gamma rays are so harmful to us that they can penetrate straight through the human body and can only really be stopped by several centimetres of lead. On Earth, gamma rays can be made in nuclear explosions, but in the universe, they are associated with great explosions in distant galaxies. These are known as gamma-ray bursts and are among the most energetic objects in the cosmos.

RADIO WAVES

We use radio waves for communication and broadcasting, but they also occur naturally, emitted by lightning and objects in space such as galaxies, pulsars and quasars. These waves were first predicted by physicist James Clerk Maxwell and later discovered to be coming from our galaxy in the 1930s by physicist and engineer Karl Jansky.

DID YOU KNOW...

There are ants in space

The ants' movements are recorded using a video camera for review and comparison with similar experiments

© NASA

Several hundred ants are currently in orbit on the International Space Station, in an experiment to see how they adapt to microgravity environments. The way ant colonies work is fascinating. They don't have a central control; no single ant can force another to do something. Instead, they use information gathered locally to assess situations, which means the behaviour of the colony depends on the local cues each ant produces. Colonies send out worker ants to search and assess new areas. This can help them find food, map foreign terrain and identify potential threats.

By studying the ways ants assess an alien environment, scientists believe they will be able to develop better search algorithms for robots. They want to create autonomous search robots that do not need a central control, much like ant colonies. These robots would then be more effective at tasks such as finding survivors immediately after a disaster takes place. This research could also impacts mobile phone networks, helping to solve problems of interference.

GREENHOUSE EFFECT
The reason Venus is so hot is its atmosphere, 96.5 per cent of which is composed of carbon dioxide, which is a deadly greenhouse gas

ACIDIC ATMOSPHERE
Lacing the atmosphere are clouds of sulphuric acid. On Venus, the acid rain is enough to kill you

Venus is the deadliest planet

SUFFOCATION
With all the carbon dioxide and sulphur, there is no room for oxygen to breathe

VOLCANIC WORLD
There are more than 1,600 volcanoes covering the surface of Venus, with evidence that some of them have violently erupted in the recent past

HOTTER THAN HELL
Venus is the hottest planet in the Solar System, with scorching temperatures of 460 degrees Celsius (860 degrees Fahrenheit) – hot enough to melt lead

CRUSHING PRESSURE
The pressure of the air at the surface is 92 times greater than on Earth. Space probes that have landed on Venus have been literally crushed

DEHYDRATION
Venus is bone dry - almost all its water molecules have escaped into space, or been split apart in the upper atmosphere

DID YOU KNOW...

Earth's atmosphere has seven atmospheric layers

99 per cent of Earth's atmosphere is within an altitude of 20km

Air pressure decreases exponentially the higher you go. But the temperature doesn't follow this smooth pattern; it falls and then rises in alternating bands.

The ground heats the lowest layer of the atmosphere, called the troposphere, so this layer gets colder the higher up you go. As the air gets colder, the water vapour precipitates and falls as rain or snow, and by the time you reach the top of the troposphere at around eight to 12 kilometres up, the air is almost completely dry. This is the start of the stratosphere, where the temperature starts rising again as a result of a large number of ozone molecules absorbing ultraviolet radiation from the Sun.

Once the ozone thins out, you reach the mesosphere and the temperature falls again, down to as low as -90 degrees Celsius. All the shooting stars you see are actually meteorites burning up as they enter the mesosphere.

Even at altitudes normally considered to be outer space, there is no hard edge to the atmosphere. The air just gets thinner and thinner. The International Space Station (ISS) actually flies through the layer above the mesosphere, which is known as the thermosphere. Even though individual gas molecules are so far apart that they can fly for a kilometre without hitting one another, there is still enough atmospheric drag to cause the ISS to lose about two kilometres of altitude per month. The final, outermost layer is the exosphere, where the atmosphere thins so much that it eventually just blends into space.

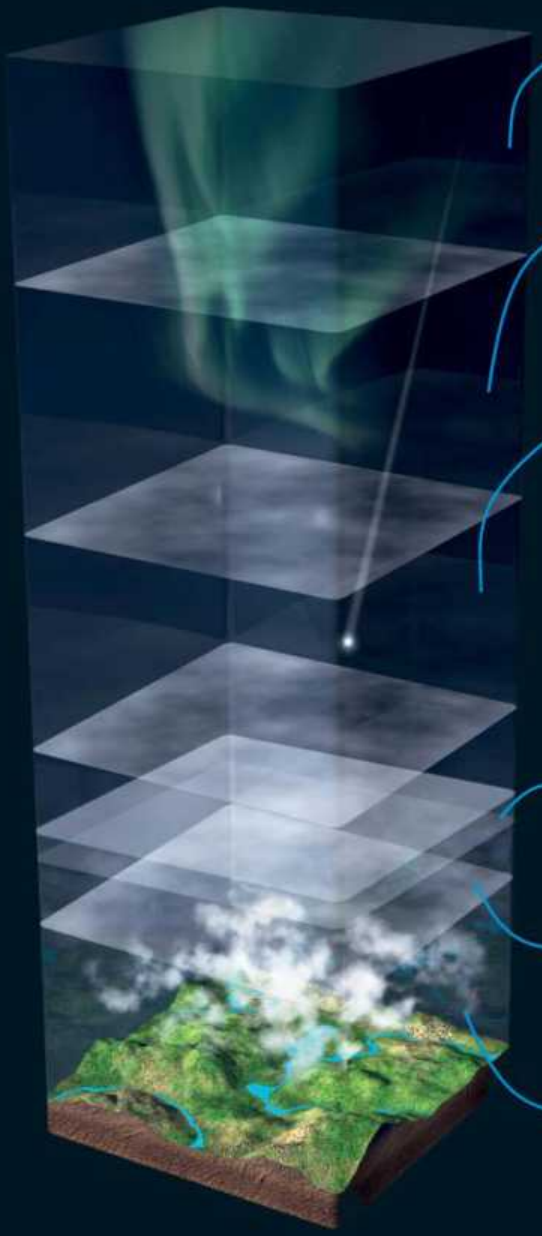
WHERE DOES SPACE START?

The atmosphere tapers off gradually, so there is no obvious point where Earth ends and outer space begins. However, we have come to a consensus based on science. The higher a plane flies, the less lift it gets from the thinner air, and the faster it must travel to stay aloft. In the 1950s, physicist Theodore von Kármán calculated that above 100 kilometres, a plane would have to travel so fast that it would be in orbit. This altitude is now known as the Kármán line, and is the internationally accepted boundary of space.

Space Shuttle Endeavour against the mesosphere (blue), stratosphere (white) and troposphere (orange)

ATMOSPHERIC LAYERS

EACH REGION OF THE ATMOSPHERE BEHAVES QUITE DIFFERENTLY FROM THE ONES ABOVE AND BELOW IT



EXOSPHERE
600 to 10,000km
Most satellites orbit here. Individual air molecules are separated by hundreds of kilometres of vacuum

THERMOSPHERE
85 to 600km
The temperature in this layer can reach 1,500 degrees Celsius but the air is so thin that it barely carries any heat energy at all

MESOSPHERE
50 to 85km
Temperatures towards the top of this layer can fall to -90 degrees Celsius

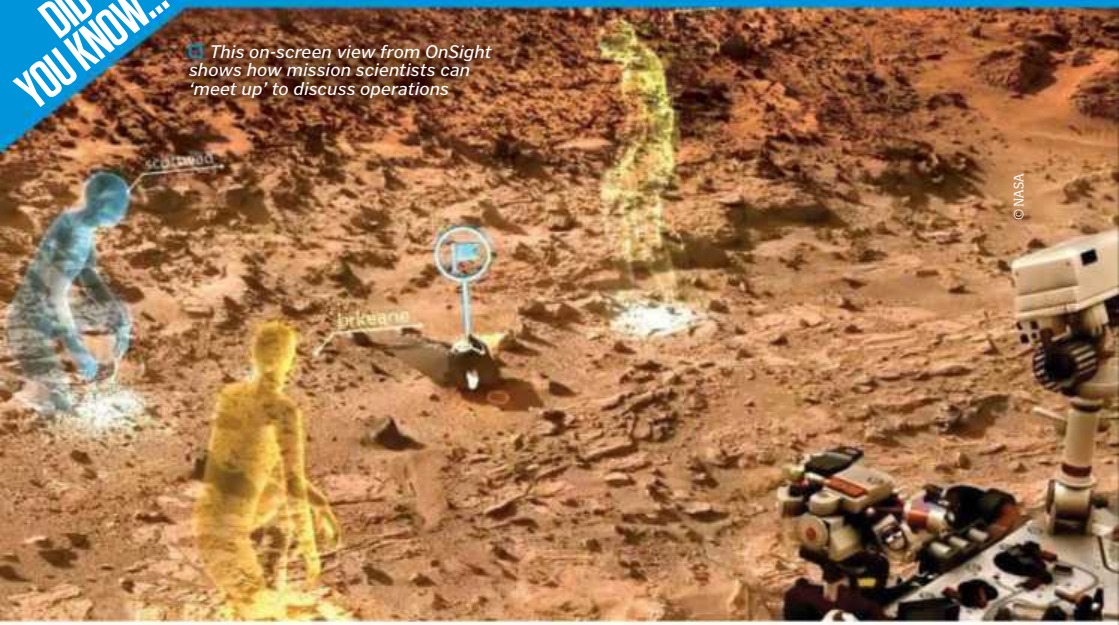
IONOSPHERE
48 to 965km
This overlaps the mesosphere, thermosphere and exosphere. It is where ultraviolet radiation ionises air molecules, creating a layer that reflects radio waves to Earth

OZONE LAYER
15 to 35km
The ozone molecules absorb between 97 and 99 per cent of the ultraviolet light reaching Earth from the Sun

STRATOSPHERE
12 to 50km
Jet planes can reach this high. Air pressure drops to one thousandth of that at sea level

TROPOSPHERE
0 to 12km
This is the densest layer of our atmosphere and is where all our weather occurs

DID YOU KNOW...



This on-screen view from OnSight shows how mission scientists can 'meet up' to discuss operations

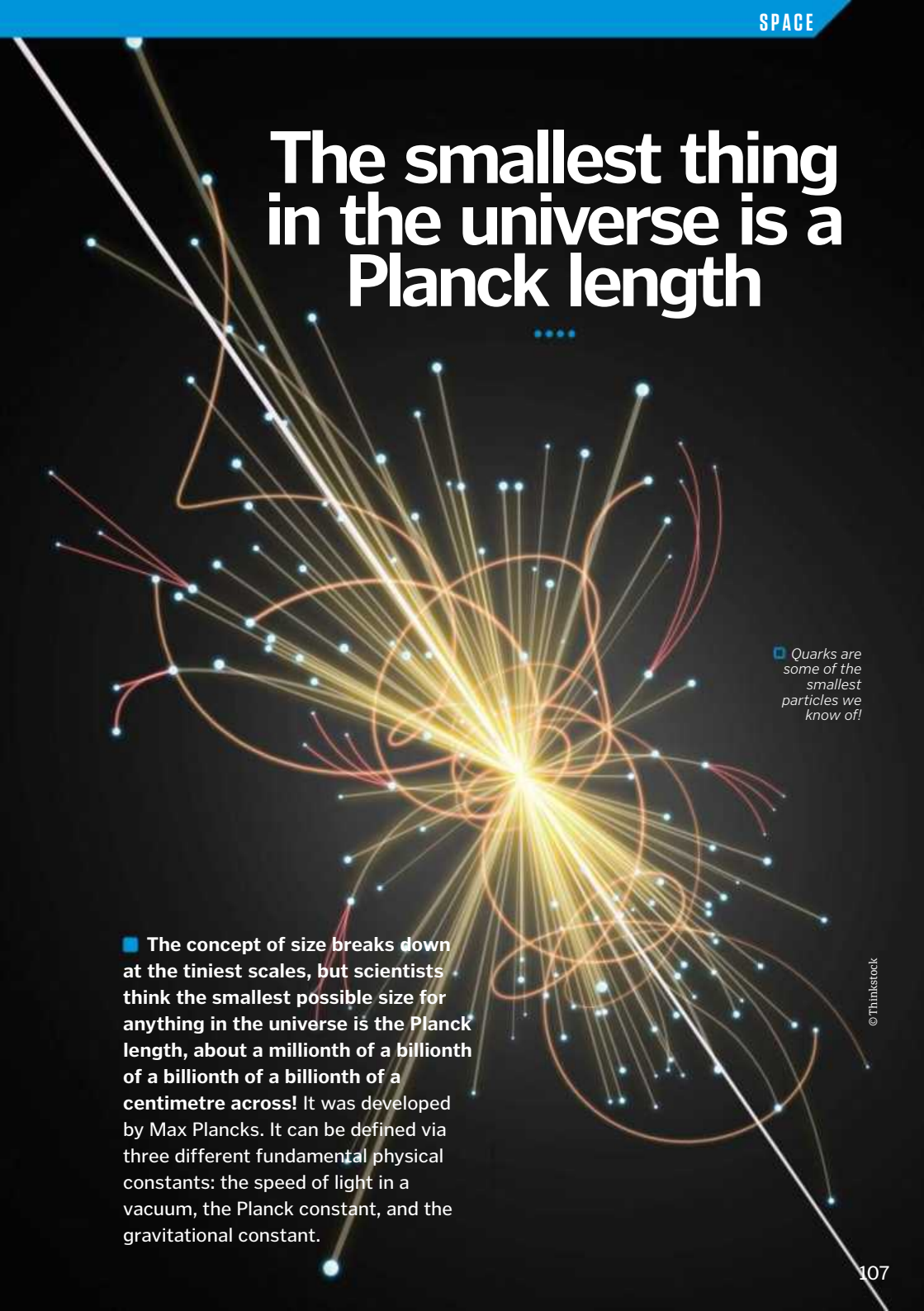
© NASA

The HoloLens will help conduct work in space

With the chance to walk on Mars still many years away, Microsoft and NASA have worked together to provide scientists with the next best thing. Using the Microsoft HoloLens headset, new OnSight software will use data gathered by the Curiosity rover to simulate Mars' environment, enabling scientists to explore as if they were standing side by side with the rover. Scientists have used pictures to navigate Mars before, by converting them into 3D stereo views. The problem with this had been that scientists struggled to recognise how far away objects were, as depth of vision is very difficult to show.

The OnSight system works using holographic computing, which blends a view of the physical world with imagery created by computer, producing a mix of virtual and real surroundings for the user. Scientists can walk around the planet's surface, bend down to closely examine a rock, and even direct the rover to take high-resolution images of interesting areas.

The smallest thing in the universe is a Planck length



Quarks are some of the smallest particles we know of!

The concept of size breaks down at the tiniest scales, but scientists think the smallest possible size for anything in the universe is the Planck length, about a millionth of a billionth of a billionth of a billionth of a centimetre across! It was developed by Max Plancks. It can be defined via three different fundamental physical constants: the speed of light in a vacuum, the Planck constant, and the gravitational constant.

DID YOU KNOW...

Galaxies can consume each other

While small galaxies create new stars from gas and dust, their more massive counterparts grow by gobbling up what's around them. The strong gravitational forces they exert pull on smaller galaxies millions of light years away, sending the two racing towards each other until they merge in a spectacular galactic feast. This can currently be seen happening between the distant Antennae galaxies, which began colliding a few hundred million years ago.

However, this galactic cannibalism has also been observed much closer to home. A stream of debris, known as the Sagittarius Stream and extending out from our very own Milky Way, is believed to contain the leftovers of its last meal. The stream contains stars that are still travelling in the direction from which they came, creating a trail of breadcrumbs leading to their original source, the nearby Sagittarius dwarf galaxy.

Eventually, it will be the Milky Way's turn to be on the menu, as it is expected to collide with the much larger Andromeda galaxy in about 4 billion years. When this happens, computer simulations have revealed that there is a one in ten chance that our Solar System will be evicted from this new galaxy, making the night sky appear far darker. However, it's more likely that we will end up closer to the core of 'Milkomeda', filling our night sky with even more stars.

THREE MORE SCARY SPACE OBJECTS

STELLAR VAMPIRES

Many of the stars in our galaxy share their space with another star, forming a binary system. The one with the lower mass can suck away the other's hydrogen, using the gas to fuel itself. This increases its mass until it strips its neighbour's stellar envelope completely.

LITTLE GHOST NEBULA

When a star the size of our Sun ran out of hydrogen and switched to using helium, its temperature soared. Eventually it expanded and became a red giant, which expelled its outer layers into space, creating a nebula. After about 10,000 years, the stellar remnant in the centre of the Little Ghost nebula will begin to cool off, forming a white dwarf star.

FRANKEN NEBULA

It may look like Frankenstein's menacing monster, but this is actually the open star cluster NGC 2467, located 20,000 light years away in the Puppis constellation. It contains hundreds of hot, massive stars belching out radiation to sculpt the clouds of the nebula into an eerie, colourful shape.

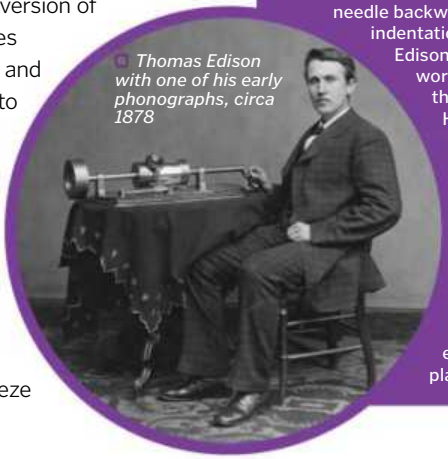
DID YOU KNOW...

Vinyl records make music through vibrations

As the vinyl disc spins on the record player, a needle – or stylus – moves along the grooves on its surface. It vibrates as it traces over the thousands of tiny bumps and the music plays. The tech seems simple compared to an iPod or a wireless speaker, yet the process to make one of these vinyl records is quite intricate.

Once engineers had perfected the recording in the studio, they would create a master disc. This was made of aluminium and coated with a black lacquer. A machine equipped with an electronic cutting stylus, or needle, would etch the grooves into the lacquer, its path directed by electrical signals from the audio. The finished record was coated with a layer of metal, such as silver or nickel, and this so-called master would form the mould for all the records that would be produced. Liquid nickel was poured into the cast to create a 'stamping record' – a negative version of the record with ridges instead of grooves – and this was connected to a hydraulic press and used to directly print into the vinyl. The stamping record would be lowered onto the vinyl (which was softened by heating with steam) to squeeze it into its final shape and imprint the audio. The disc was then removed, hardened in a water bath, and cut to size using a sharp blade.

Before the records could be sold, a handful were inspected for sound quality. Flawed copies were melted and pressed again.



Thomas Edison with one of his early phonographs, circa 1878

THOMAS EDISON'S PHONOGRAPH

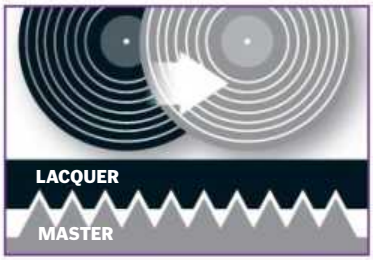
The inventor of the electric light bulb and the motion picture camera was also the grandfather of modern record players. In 1877 Thomas Edison and his assistants were working on a way to record telegraph messages using paper strips wrapped around rollers. He attached a needle to the diaphragm in a telephone mouthpiece, which vibrated with sound energy when someone spoke, creating squiggles on the paper. Once the sound was recorded in this way, it could be replayed by rotating the cylinder in the opposite direction, which dragged a second needle backwards through the indentations the first had made. Edison and his team produced a working prototype, recording their own rendition of Mary Had A Little Lamb.

Within six months, Edison had replaced the paper strips with tinfoil to improve the sound quality, and the first phonograph was born. Edison's work paved the way for other inventors to refine and improve the recording process, which eventually led to the record player and vinyl records.

MAKING A HIT RECORD

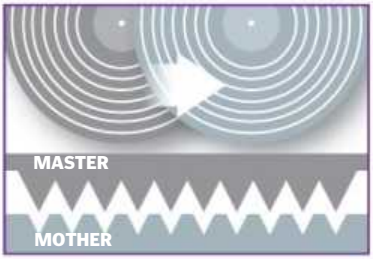
1. CUTTING THE LACQUER

Tiny grooves were etched into the lacquered discs by a record-cutting machine's needle. This was guided by the audio of the song that the vinyl was being produced for and the first step in the process.



2. PRODUCING THE MASTER DISC

The lacquer was not tough enough for the production process, so it was then coated with a more durable layer of silver or nickel. It was then peeled off and discarded, leaving the metal master ready to create the mother.



3. CREATING THE 'MOTHER'

The master disc was re-cut once more to produce the mother record. This was then replated with silver or nickel to create the 'stamper', which could then be used to mass produce the record in great quantities.

4. STAMPING THE VINYL

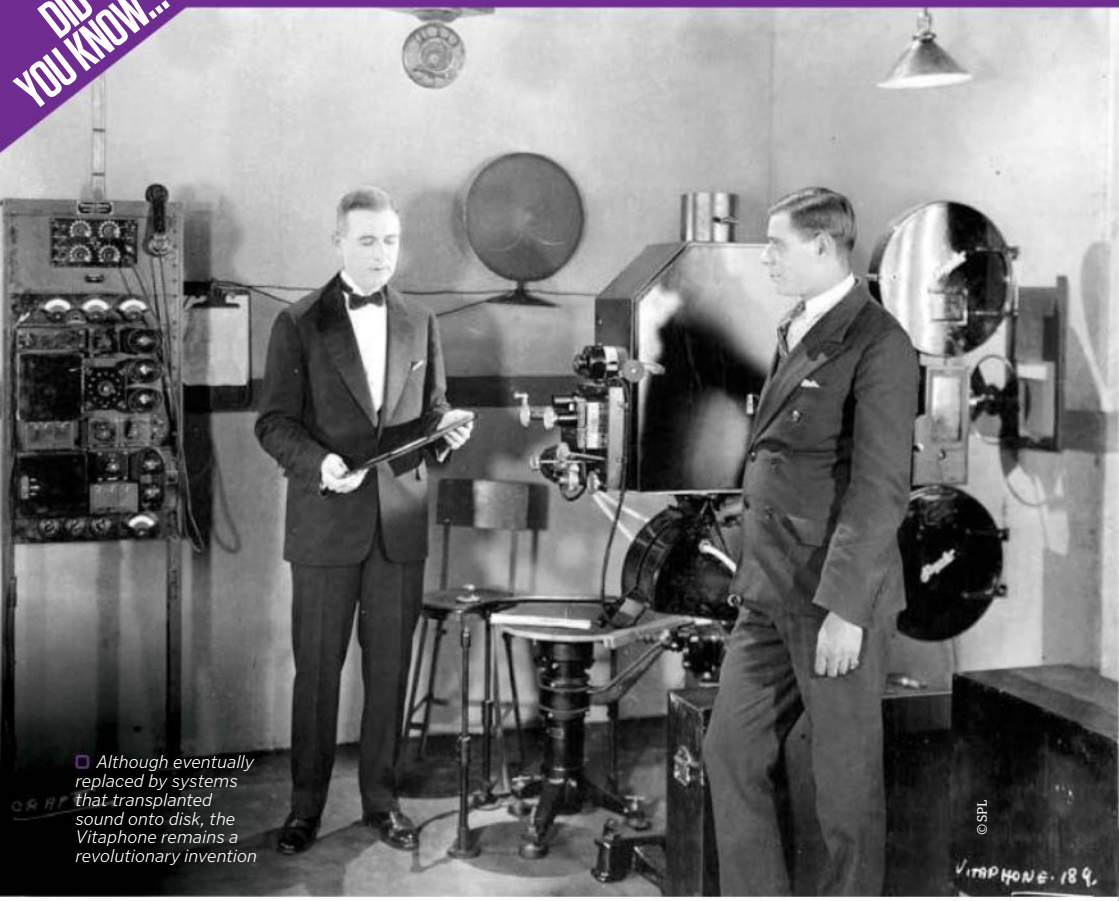
A fresh piece of vinyl was sandwiched between the stamper and a hydraulic press. Steam was used to soften the vinyl, enabling the stamper to imprint it with the grooves required to create the song.

5. QUALITY CONTROL

Before the finished vinyl could be sent to shops, a few individual records were played to check that they were working correctly and that there were no imperfections. Faulty records were melted.

"Before the records could be sold, a handful were inspected for sound quality and imperfections. Flawed copies were melted down and pressed again by the stamper"

DID YOU KNOW...



Although eventually replaced by systems that transplanted sound onto disk, the Vitaphone remains a revolutionary invention

The first film with audible dialogue was The Jazz Singer

Films have long represented a popular form of entertainment, but for much of the early-20th century, they were restricted to the silent format. Soon, however, this would all change.

Inspired by Thomas Edison's phonograph and Lee de Forest's Audion tube, the Vitaphone was created by Western Electric, and in turn was bought and developed further by Warner Bros. The Vitaphone comprised a film projector rigged up to a record player, with the sound being played over the footage of the film. In turn, the sound was amplified so that it was more audible to the audience, with a projectionist on hand to make sure the footage and sound were in sync.

The first sound movie to use the Vitaphone system was Don Juan on 6 August 1926 – although since there was no dialogue, the honour of the first 'talkie' is credited to The Jazz Singer, which was released on 6 October 1927.

The 'Butcher crocodile' was king before dinosaurs

A 3D model of the creature was created from scans of its fossils

When the supercontinent Pangaea was breaking apart, 2.7-metre (nine-foot) tall, sharp-toothed creatures roamed the area that would become North Carolina in North America. Palaeontologists have recently discovered parts of the skeleton belonging to Carnufex carolinensis, an ancestor of today's crocodiles. Nicknamed the 'Carolina Butcher', it is believed to have used its blade-like teeth to slice flesh from its prey, likely to have been armoured reptiles and the early relatives of large mammals. As its forearms were so short, it is also suspected the creature walked on two legs, much like a T-rex.

"As its forearms were so short, it is also suspected the creature walked on two legs, much like a T-rex"

DID YOU KNOW...

The Sainte-Chapelle only took around seven years to build

The Sainte-Chapelle, or 'Holy Chapel', was commissioned by King Louis IX of France more than 770 years ago. The reason? To house his most prized possessions – what was believed to be the authentic 'crown of thorns' worn by Christ at his crucifixion, and fragments of the Holy Cross. The king did not want these relics to become lost, so he decided to buy them and build an appropriately elaborate church to display them in.

It is a truly stunning example of medieval architecture; nothing like this had ever been constructed before in history. The fact it was built between around 1241 and 1248 is even more incredible considering the Notre Dame took more than 200 years to build from 1163. The church walls act essentially as window frames for the 15 immense stained glass panels. The stained glass mainly depicts famous Bible stories, including parts from the Old Testament such as Genesis and Exodus. Also shown is the history of the holy relics, from their discovery by Saint Helen to their eventual arrival in the French Kingdom. Restorations of the stained glass in the 19th century remained faithful to the original designs, and further work is underway today in order to protect the glass from deterioration for years to come.

When you think of medieval architecture, you may automatically think of dark, dingy buildings. The Sainte-Chapelle defies this preconception, with a majestic design that shows off the power of light, embracing it to create a truly breathtaking church.

PRODUCING STAINED GLASS

The soaring stained glass windows are Sainte-Chapelle's trademark

Making stained glass to a high standard is much easier now than it would have been during the Sainte-Chapelle's construction in the 13th century. Throughout this period, glass factories were located in areas with a good supply of silica such as sand, an essential ingredient for the mix. The overall process was much the same then as it is today; first you mix the silica, potash and lime along with a metallic oxide, which provides the colour. This could be copper oxide, which can produce blue, green or ruby colours depending on the conditions. These ingredients are then heated in a furnace to around 1,371 degrees Celsius (2,500 degrees Fahrenheit), creating molten glass. This stage was problematic in medieval times, as creating this heat with the techniques available was a lengthy process and hard to maintain. The glass can then be rolled into thin sheets and left to cool before cutting to the desired size.

ENGINEERING breakthrough
The thin walls between each glass panel were able to support the considerable weight by directing it toward their base

CHURCH SPIRE
This has been replaced on numerous occasions; one spire was destroyed during the French Revolution

ROSE WINDOW
The inclusion of this window is characteristic of Gothic architecture, seen in many cathedrals of this age in northern France

STAINED GLASS
Each window group has four lancets, with three rose windows above them

LOWER CHAPEL
This functioned as the parish church, serving everyone who resided in the royal palace

STAINED GLASS PRESERVATION
Recently, an innovative layer of protective glass has been applied to many of the stained glass windows

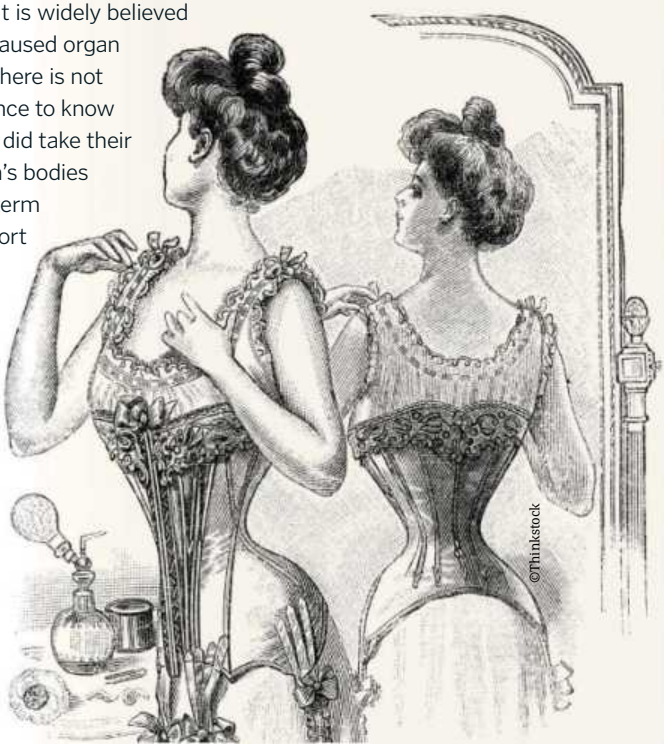
DID YOU KNOW...

Corsets were worn 3000 years ago

The corset is infamous for crushing women's waistlines into an hourglass shape. The garment's origins date back millennia, with early examples believed to have been worn in ancient Crete 3,000 years ago.

The waist-cinching trend peaked in the 19th century as hourglass figures became the focus of fashion. Victorian corsets were made from coutil, a fabric famed for its resistance to stretching. This was reinforced with strips of rigid materials, such as wood, whalebone or even steel to provide structure. Tight-lacing was commonplace, which involved someone (usually a servant or lady's maid) pulling the laces of the wearer's corset to achieve the smallest waist size possible.

Corsets were so fashionable that children were given training versions to prepare them for the torturous ordeal. This, along with women starving themselves to stay thin, was a dangerous combination. It is widely believed that corsets caused organ damage, but there is not enough evidence to know for sure. They did take their toll on women's bodies though: long-term use could distort the lower ribs and decrease lung capacity.



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Tiny waists were the height of fashion in the Victorian era

The West's demand for collecting shrunken heads in the early-20th century caused tribes to increase their kill rate

Amazonian tribesmen shrunk the skulls of their enemies

Shrunken heads are a somewhat alien concept to modern society, yet it is believed they were still being produced during much of the 20th century. The only recorded examples of head shrinking are in South America by Jivaroan tribes in Peru and Ecuador.

Tribesmen shrunk people's decapitated heads due to their belief of a vengeful spirit, or muisak, inhabiting the body. To stop this spirit and to gain power over the victim's soul, the hunters removed their enemies' heads and shrank them.

First, the warriors would remove the skin and hair from the skull, and seal the eyes and lips shut with pegs. The head skin would then be boiled for half an hour, shrinking it to around a third its original size. The eyes and lips were then sealed more tightly by being sewn shut with woven fibre. By filling the head with hot stones and sand through the hole at the base of the neck, it was possible to shrink it even further until the desired size was achieved. The finished product was typically worn around the warrior's neck, signifying victory in battle.

DID YOU KNOW...

Cromwell ordered for the Crown Jewels to be melted

Along with Buckingham Palace, one of the most famous things about the British monarchy is the incredible collection of crowns, orbs, sceptres and precious stones that makes up what's collectively called the Crown Jewels.

Stored in the Jewel House of the Tower of London since the beginning of the 14th century, the collection has been a symbol of the monarchy ever since the coronation of Edward the Confessor in 1042. It was for this reason that many valuable pieces were lost as Lord Protector Oliver Cromwell ordered the Crown Jewels to be melted. As they represented the monarchy's wealth and power, gold items were melted down and jewels sold. The only items that remained were the Anointing Spoon and three ceremonial swords – the Swords of Temporal Justice, Spiritual Justice and Mercy.

The collection was rebuilt in 1660 after Charles II regained the throne. He commissioned replicas of the destroyed pieces at a cost of £13,000, which today would be around £1.7 million ($2.8 million).

The Crown Jewels do have a practical purpose, though, as they form the regalia that accompanies every coronation ceremony. The crown that was used for Queen Elizabeth II's coronation is St Edward's Crown. The jewel-encrusted golden headpiece weighs a hefty 2.23 kilograms (4.92 pounds), or about the same as a medium-sized rabbit.

THE AMPULLA
During the coronation ceremony, the head of this golden eagle is unscrewed as it contains the oil used to anoint the incoming monarch

CORONATION SPOON
The oldest surviving piece of the collection. Oil is poured from the Ampulla onto the Anointing Spoon, where it is placed on the monarch's forehead by the Archbishop of Canterbury

Queen Elizabeth II wearing St Edward's Crown at her coronation

ST EDWARD'S CROWN
This gold crown is inlaid with sapphires, topazes, citrines, tourmalines and amethysts. It is the crown used at the monarch's coronation

IMPERIAL STATE CROWN
Every time the monarch opens Parliament, this crown is the one they wear. It contains an incredible 3,000 gems including the Second Star of Africa

THE SOVEREIGN'S ORB
The other item handed to the monarch during their coronation. A hollow gold sphere featuring sapphires, rubies and emeralds, while the cross on top of it is inlaid with diamonds. It represents power and Christianity

ALTAR SET
Part of Charles II's extravagant rebuilding included a full altar set, including a golden chalice and a plate used for communion

THE ARMILLS
These gold and enamel bracelets are lined with velvet and worn by the monarch, and are thought to represent wisdom

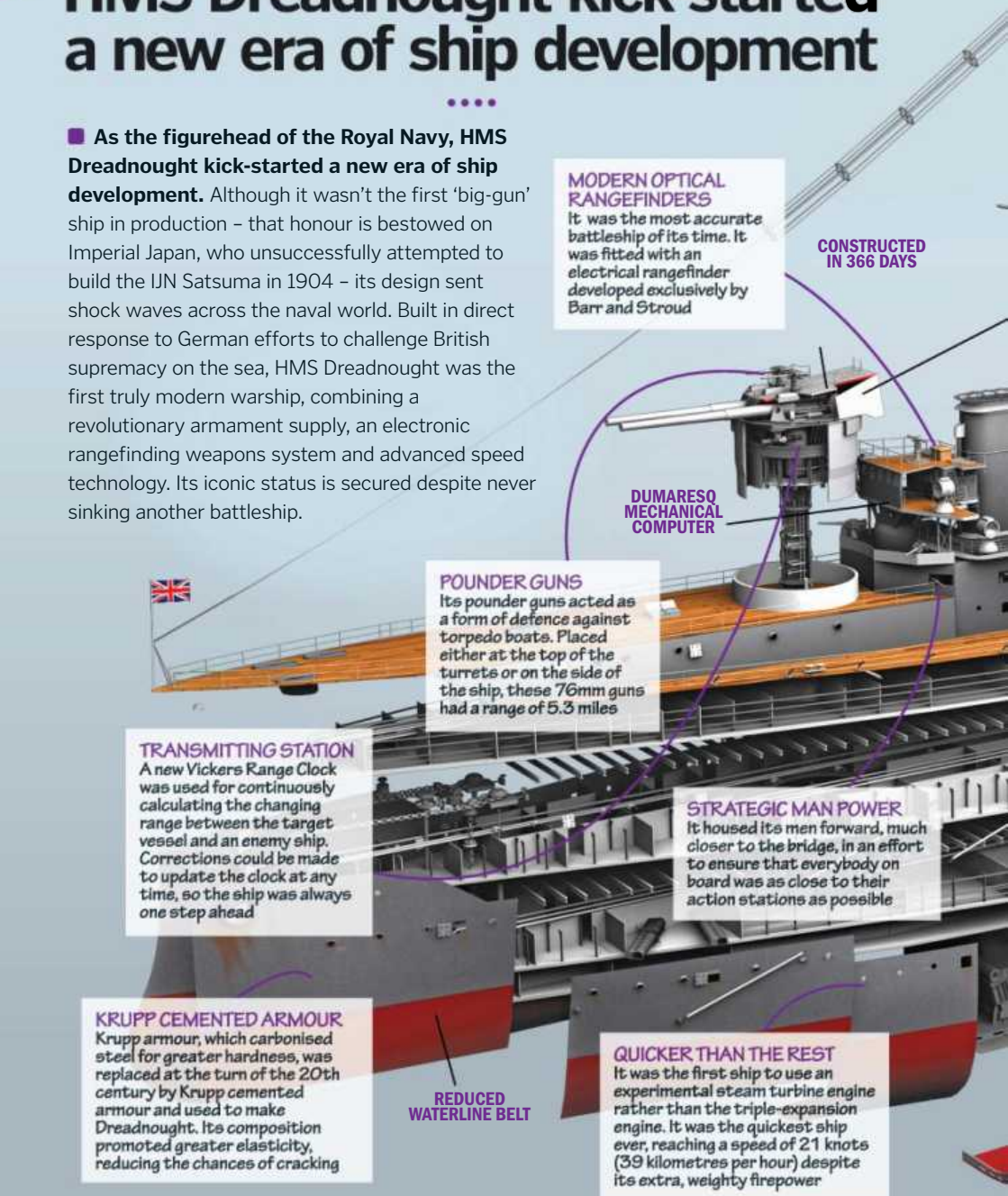
SPURS
No longer worn by the monarch, the spurs are made from gold, velvet and gold thread and were first used for the coronation of Richard the Lionheart

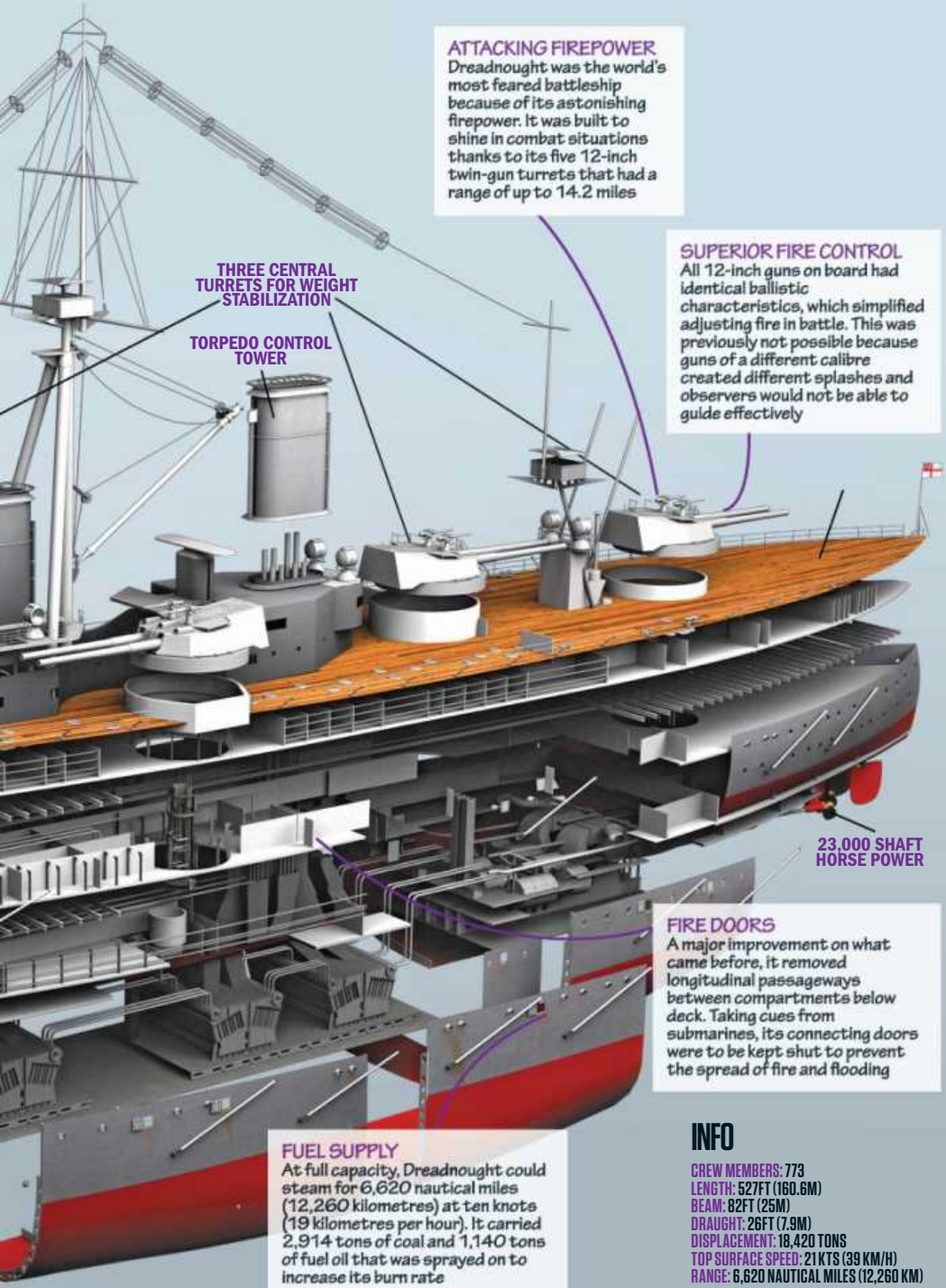
THE SOVEREIGN'S SCEPTRE
Topped with the 530.2-carat Star of Africa, the Sovereign's Sceptre is handed to the new monarch at their coronation. It represents the sovereign's good governance and temporal power

DID YOU KNOW...

HMS Dreadnought kick-started a new era of ship development

As the figurehead of the Royal Navy, HMS Dreadnought kick-started a new era of ship development. Although it wasn't the first 'big-gun' ship in production – that honour is bestowed on Imperial Japan, who unsuccessfully attempted to build the IJN Satsuma in 1904 – its design sent shock waves across the naval world. Built in direct response to German efforts to challenge British supremacy on the sea, HMS Dreadnought was the first truly modern warship, combining a revolutionary armament supply, an electronic rangefinding weapons system and advanced speed technology. Its iconic status is secured despite never sinking another battleship.





ATTACKING FIREPOWER

Dreadnought was the world's most feared battleship because of its astonishing firepower. It was built to shine in combat situations thanks to its five 12-inch twin-gun turrets that had a range of up to 14.2 miles

SUPERIOR FIRE CONTROL

All 12-inch guns on board had identical ballistic characteristics, which simplified adjusting fire in battle. This was previously not possible because guns of a different calibre created different splashes and observers would not be able to guide effectively

THREE CENTRAL TURRETS FOR WEIGHT STABILIZATION

TORPEDO CONTROL TOWER

23,000 SHAFT HORSE POWER

FIRE DOORS

A major improvement on what came before, it removed longitudinal passageways between compartments below deck. Taking cues from submarines, its connecting doors were to be kept shut to prevent the spread of fire and flooding

FUEL SUPPLY

At full capacity, Dreadnought could steam for 6,620 nautical miles (12,260 kilometres) at ten knots (19 kilometres per hour). It carried 2,914 tons of coal and 1,140 tons of fuel oil that was sprayed on to increase its burn rate

INFO

CREW MEMBERS: 773
LENGTH: 527FT (160.6M)
BEAM: 82FT (25M)
DRAUGHT: 26FT (7.9M)
DISPLACEMENT: 18,420 TONS
TOP SURFACE SPEED: 21 KTS (39 KM/H)
RANGE: 6,620 NAUTICAL MILES (12,260 KM)

DID YOU KNOW...

It could take a monk years to copy out a long book such as the Bible

Social status didn't dictate whether or not you could become a monk

Medieval monks were men who dedicated their lives to serving God and their local community, and would live most of their lives within the walls of a monastery. Any man could become a monk, no matter what their social status, and some parents would even hand their child over to a monastery to be educated and bought up to perform religious duties.

However, an adult actively seeking to become a monk would first have to complete a one-month postulancy period before receiving training as a novice for one year. They would then take their simple vows, and after a further four years of service, take their final, or solemn, vows. These differed depending on which religious order the monk belonged to, but usually included the three Benedictine vows: the vow of poverty, meaning they had to give up all their belongings; the vow of chastity, meaning they could never marry; and the vow of obedience, meaning they had to follow the rules of the monastery.

These rules were made by the abbot, the monk in charge of the monastery, and involved a strict routine of work and prayer. Each monastery was also seen as an important part of the local community, as the monks would provide medical care for the sick and hospitality for travellers and the poor. In return, local families would pay one tenth of their yearly earnings to the Church, known as tithes, meaning some monasteries became incredibly wealthy.

LIFE AS A MONK

The daily life of a monk centred around prayer. The main prayer book used was the Book of Hours, which was divided into eight sections, intended to be read at specific times of day. When they weren't praying, the monks were required to carry out manual labour and chores to aid the running of the monastery. Their work depended on their personal interests and skills but could include farming the surrounding land, making wine, cooking the food, washing the clothes, copying manuscripts to preserve them for future generations and educating novice monks.

HAIRSTYLE
To show their commitment to the Church, monks had their scalp shaved, leaving a small strip of hair around the head in a practice known as tonsure

SCAPULAR
Over the tunic they wore a scapular, a piece of woollen cloth with a built-in hood, or cowl

HAIR SHIRT
Some monks would impose suffering on themselves by wearing itchy shirts made of hair underneath their clothes

DAY TO NIGHT
Monks would sleep in their tunics, only removing them for washing, but the scapular was only worn for work and prayer

TUNIC
Each monk was given a floor-length tunic made of wool, which they would tie around their waist with rope

CLOTHING COLOUR
The colour of a monk's clothes indicated the religious order he belonged too. For example, Benedictine monks wore black, while the Carmelites wore brown

FOOTWEAR
Most monks wore shoes or sandals, but some would go barefoot to show sorrow for their sins

A STRICT SCHEDULE

4:30	Get up
5:00	Lauds prayer service
6:00	Prime prayer service
6:30	Breakfast
9:00	Terce prayer service
9:30	Work
12:00	Sext prayer service
13:00	Midday meal
13:30	Private reading & prayer
15:00	Nones prayer service
15:30	Work
17:00	Vespers prayer service
18:00	Compline prayer service
18:30	Bed time
02:00	Matins prayer service

DID YOU KNOW...

A mechanical 20th century pencil sharpener, with gearing and teeth

The sharpener is a French invention

Although the exact origins of the pencil are uncertain, its growing popularity demanded a far less time-consuming and far more precise method of sharpening it than to slash away with a knife.

The first attempt came in 1828 from French mathematician Bernard Lassimone, who placed two blades at 90 degree angles on a block of wood, but this method of grinding down the pencil to a point wasn't any faster than the traditional method.

The mechanism we're familiar with today came in 1847 from another Frenchman, Therry des Estwaux, who invented a cone-shaped device with a single blade that when turned would neatly and evenly shave away at the pencil on all sides.

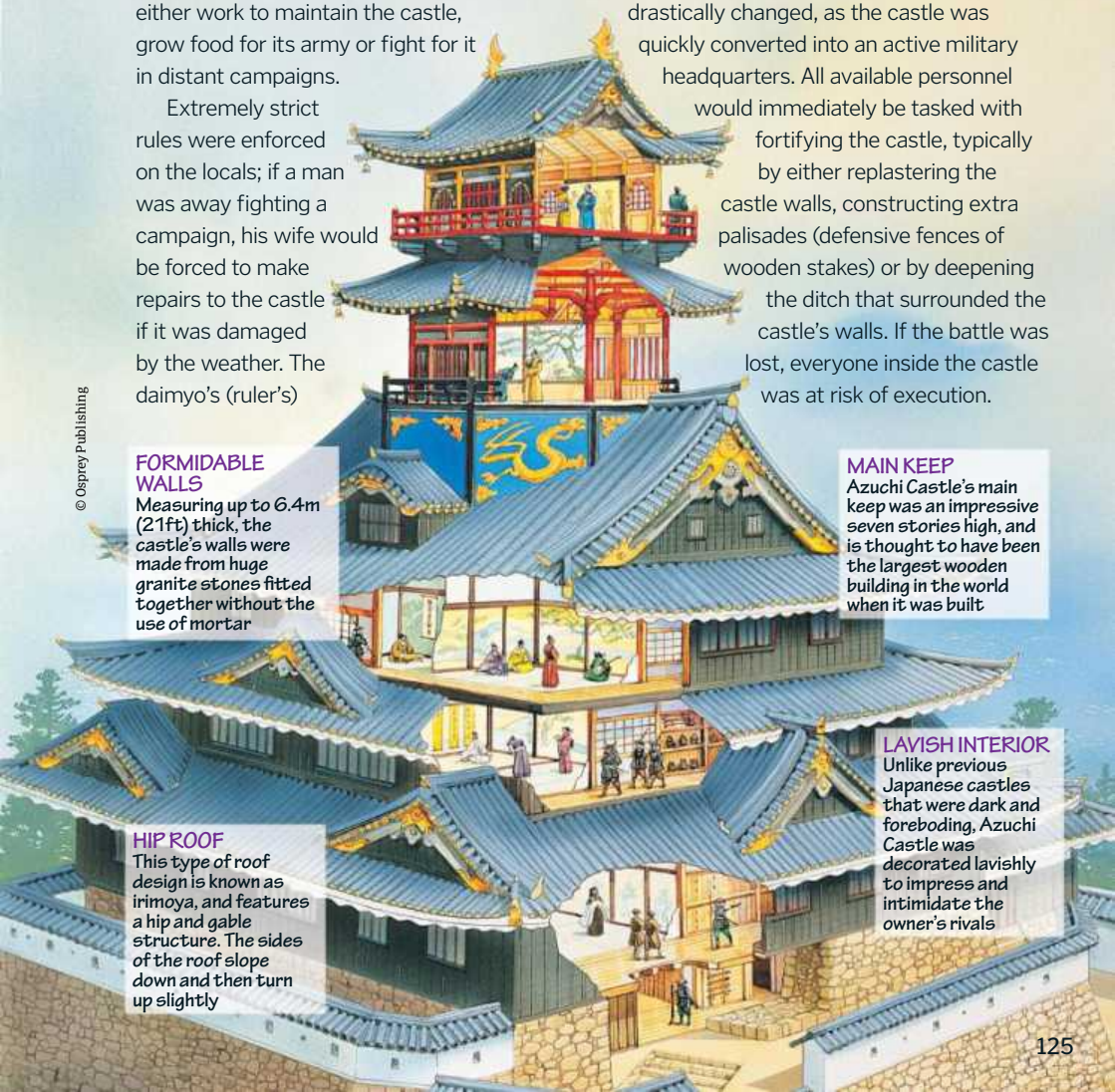
The French may have paved the way, but it was America that made waves. In the 1850s, US inventor Walter K Foster mass-produced a similar cone design and by 1857 his company was cranking out 7,200 sharpeners a day.

Japanese castles were the most important structure during war

A medieval Japanese castle was not only the geographical centre of a ruler's territory; it was also their most important structure. The population relied on the castle to defend them when war began; during times of peace they would either work to maintain the castle, grow food for its army or fight for it in distant campaigns.

Extremely strict rules were enforced on the locals; if a man was away fighting a campaign, his wife would be forced to make repairs to the castle if it was damaged by the weather. The daimyo's (ruler's) needs were always the priority. If a single person failed to complete their task, a punishment would be imposed on the entire company.

When war began, the daily lives of both the garrison and the general population drastically changed, as the castle was quickly converted into an active military headquarters. All available personnel would immediately be tasked with fortifying the castle, typically by either replastering the castle walls, constructing extra palisades (defensive fences of wooden stakes) or by deepening the ditch that surrounded the castle's walls. If the battle was lost, everyone inside the castle was at risk of execution.



FORMIDABLE WALLS
Measuring up to 6.4m (21ft) thick, the castle's walls were made from huge granite stones fitted together without the use of mortar

MAIN KEEP
Azuchi Castle's main keep was an impressive seven stories high, and is thought to have been the largest wooden building in the world when it was built

LAVISH INTERIOR
Unlike previous Japanese castles that were dark and foreboding, Azuchi Castle was decorated lavishly to impress and intimidate the owner's rivals

HIP ROOF
This type of roof design is known as irimoya, and features a hip and gable structure. The sides of the roof slope down and then turn up slightly

DID YOU KNOW...

The Pantheon has elements of Greek design

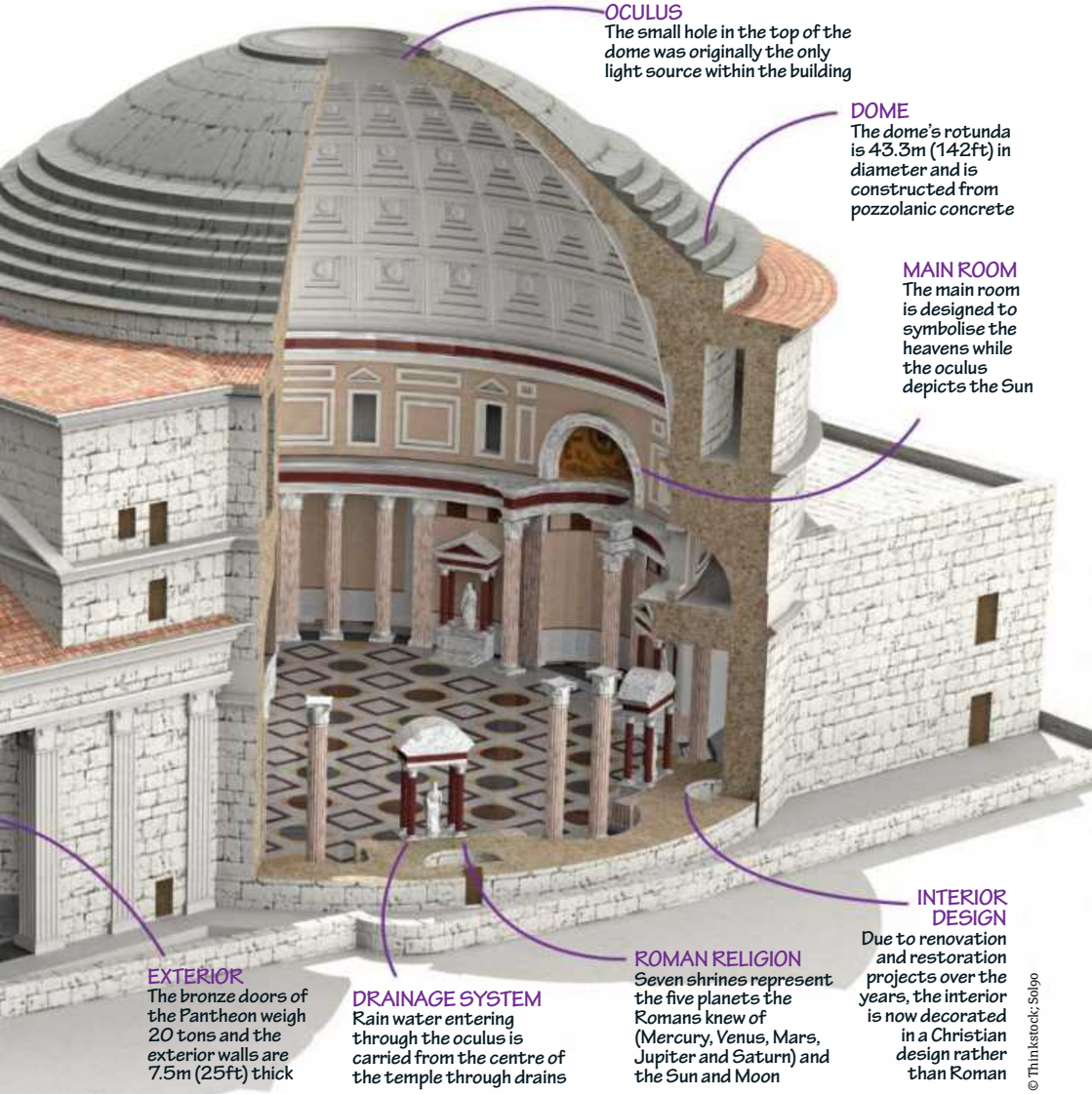
You may have heard of the Roman Emperor Hadrian – he has a wall named after him in Northern England – but his most famous and influential project is the Pantheon. Nestled in the heart of Ancient Rome, it is the largest unreinforced concrete dome in the world. It was completed in around 125 CE after the original was burnt to a cinder. The Pantheon served as both a temple to the gods and also as a place where the emperor could make public appearances.

The front of the structure is Greek in style and is not too different from many of the buildings in Ancient Athens in its pomp. The remainder is a classical Roman style and contains an 8.8-metre (29-foot) oculus in the dome. While the Greek columns were made of marble, the Roman arches inside are constructed from brick. The vast dome is held up by internal arches and step rings and signifies a major breakthrough in architecture. These techniques enabled the Romans to build the biggest structures seen in that period.

With the fall of the Western Roman Empire, Europe experienced a period of architectural decline known as the Dark Ages. As cities across the empire were ransacked, many of the great Roman buildings were destroyed by barbarian hordes. Currently, the building serves as a symbolic tomb for the old Italian monarchy and as a constant reminder of the greatness of Ancient Rome.

PRETENDERS TO THE CROWN

From the Panthéon in Paris to the Pantheon of National Revival Heroes in Bulgaria, the legendary structure has influenced building style around the world. You'll notice the symmetrical design with rows of Corinthian columns reproduced in the US Capitol Building and the Jefferson Memorial in Washington, USA, and a little closer to home in the Villa Almerico-Capra in Italy. Ancient Roman architecture has been the template for many structures and since the Pantheon is undoubtedly one of the best preserved of them all, it's only natural to look to it for inspiration. As they say, imitation is the sincerest form of flattery.



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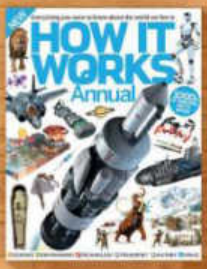

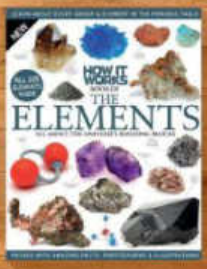

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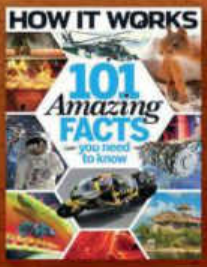

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HOW IT WORKS

DID YOU KNOW?

Revealing the truth behind life's biggest mysteries

Other planets can have auroras too

The future in motion

Ground-breaking science

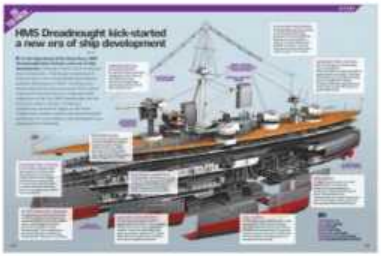
Pencil sharpeners were French

The world around us

Travel into outer space

You can make video calls to your pet

Explore the past



Breath-taking technology

Your ashes can be turned into diamonds

Sirens do not flash

Ice skaters use the power of physics